POWER PLANT ENGINEERING

GENERATION, TRANSMISSION AND UTILIZATION OF STEAM, ELECTRIC, DIESEL AND HYDRAULIC POWER

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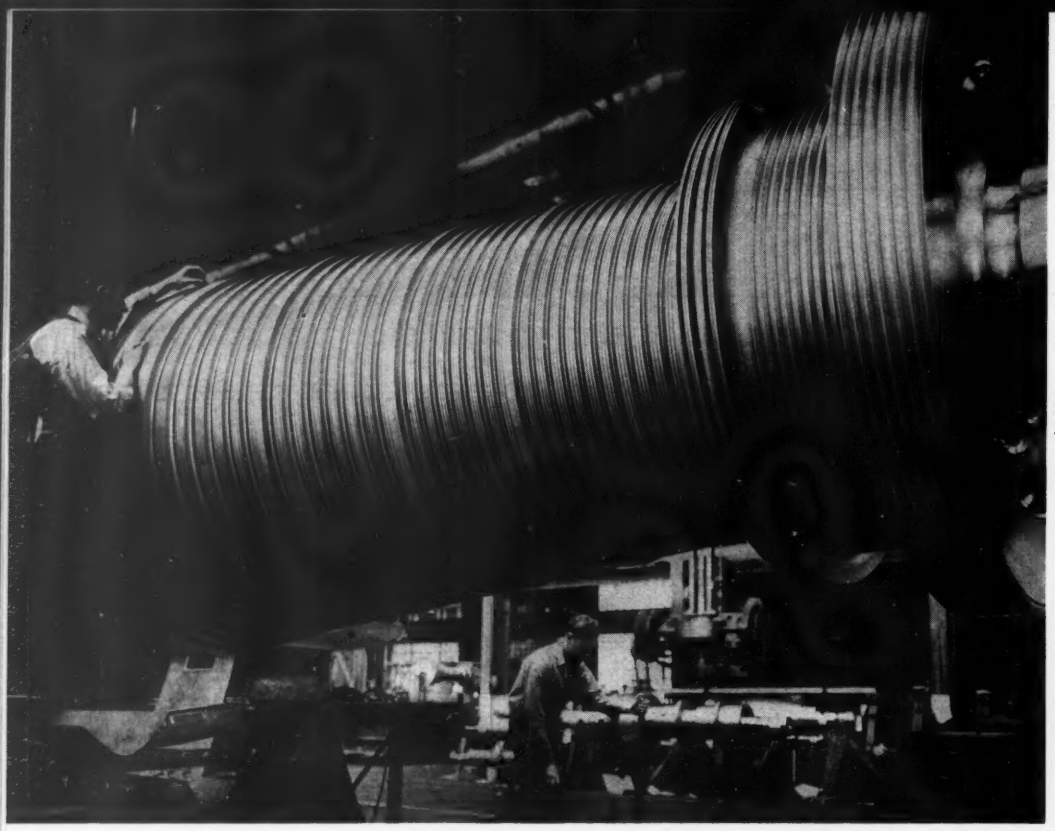

MACHINIST'S DELIGHT

FORGED from a single steel ingot weighing 293,000 lb., this polished and beautifully machined turbine rotor must be a joy and a delight to every machinist's eye. For it takes skill and craftsmanship and knowledge of a high order coupled with unusual mechanical resources to fashion a piece of work like this and only a mechanic trained in the art of working in steel can fully appreciate the delicacy of the operations involved in its construction. Imagine the task of boring a hole through the center of this rotor from end to end! That, alone, is a task beyond the comprehension of ordinary mortals not familiar with the capabilities of modern machine tools, yet that was only one of many operations necessary to turn a rough, almost shapeless, ingot into the smooth, accurately finished rotor you see here.

This is the most massive single piece rotor ever manufactured by Westinghouse. Over 20 ft. long and 5½ ft. in diameter, it is part of the new 30,000-kw. generating unit being built for the Quindaro Power Station at Kansas City, Kansas. The weight of the total finished rotating element of this machine will be 182,000 lb. or 91 tons.

Although this is not a large turbine as modern turbines go, it is representative of the fine construction that characterizes all turbines, today. The turbine has become, perhaps, our most important single machine for the bulk of the world's electric power is produced by turbines of one form or another. It is a far cry from Samuel Insull's first 5000-kw. turbine at Fisk Street Station shown on page 576 of this issue to machines of the type shown above and many changes have taken place in turbine construction since that day in 1900 when, with breathless excitement they first brought that early machine up to speed, yet the fundamental principles have not changed. Though made in an endless variety of sizes, styles and speeds, the principles remain simple and easily understood. It is because of this simplicity that the turbine has become so popular. As pointed out by L. E. Newman in the series of articles on Modern Turbines now appearing in these pages, the turbine is the most flexible of all prime movers; no other prime mover could be built any more tiny and no other prime mover has been built as large.

The turbine has long ceased to be a thing of wonder to the power engineer and under ordinary circumstances we would hesitate to present a series of articles dealing with its principles but these articles by Mr. Newman present the facts about turbines in so unusual a manner that we feel certain that they will make even the most prosaic of turbine operators take a new interest in the machines under his care. We earnestly recommend these articles to your attention.

WITH THE EDITORS

Maintenance—Early or Late

MAINTENANCE is a real cost involving both material and labor but like the intangible item depreciation it may be juggled so as to give misleading total cost figures for a limited period. In a well regulated plant, a capable and experienced operating force will know just about how much a piece of equipment will stand safely and take steps to overhaul it before the danger point is reached.

During the depression many companies cut maintenance work to the bone in order to reduce immediate operating costs although this was done with the knowledge that it was false economy and would be paid for dearly later on. During the same period many a man postponed a pair of half soles, well knowing that further wear would ruin the shoes completely.

The modern idea of maintenance is to get the maximum out of a machine but keep it always in a safe condition. What this may be depends upon the machine and service. One large company has both a service and time standard. Generating units are overhauled after a given number of hours' service or after a certain period of time which is even shorter.

Of course emergencies cannot be avoided entirely, and standby equipment must be provided to take care of this. The same company maintains standby sufficient to carry the load with the largest unit out of service. Sometimes the standby is reduced with the expectation of dropping some of the load under emergency conditions. The standby investment must be balanced against the loss of revenue from reduced power output. Some industrial plants prefer to pay the utilities a standby charge rather than invest large sums in idle equipment.

The point is, however, that standby equipment is tied in with a well-planned maintenance schedule. This allows work to be done thoroughly without a rush in slack periods and avoids expensive emergency repairs. It is the old case of a stitch in time saving nine, a self apparent truth that is difficult for many to see.

The Individual in Industry

IN OUR HASTE to finish the particular task of the day, little thought is given to the influence upon, or importance of that accomplishment to associates, the employing company, the immediate neighborhood and the industry of the country in general. Too often we consider our jobs as personal affairs practically independent of outside considerations.

True it is that the work of almost any individual in an organization may be picked up and carried on by another without much impairment in efficiency thus testifying to the unimportance of the individual, nevertheless in his daily occupation each worker has a responsibility that reaches well beyond the walls of his workshop.

Were we to investigate the sources of the raw materials that enter into the construction of almost any modern power plant it is conceivable that nearly every state in the Union may be found contributing in some way toward the perfection of this plant, such is the dependency of one section of the country upon others. Raw materials, however, may, in the course of manufacture, travel back and forth from district to district several times before they reach their final destination for use in a power plant. At each stopping place workmen add their touch in the way of preparing and refining of materials, moulding, casting, machining, baking, assembling, soldering, welding, polishing and a thousand other necessary detail processes that go to make up a finished product. Perfection demands that each one of these tasks be performed with precision otherwise flaws may occur that will cause unsatisfactory operation, if not disastrous accidents.

One of the favorite pastimes of engineers is to conjecture what would happen if the supply of electric power should suddenly cease in any of our industrial centers. The answer is always chaos, industry stopped, lights out, households inconvenienced, sanitation impaired, all of which was too vividly observed during the floods and labor strikes of last spring. Such conditions are of course extreme but everybody connected with power plants is familiar with trouble resulting from failure of equipment, which can nearly always be traced to the neglect of some individual responsible in some way for its care or operation.

Individuals in industry may well be likened to parts of an electrical net work, the failure or impairment of any one of which either throws an extra burden upon others or puts certain dependent sections completely out of service.

A happy go-lucky, irresponsible attitude toward one's work may result in freedom of mind for a time but the rewards in the industrial fields most certainly go to the individuals who have a true picture of their responsibility and perform their tasks with due care.

70 Per Cent To Go

WHILE DISCUSSING the opportunity for young men in the utility field, H. P. Liversidge of the Philadelphia Electric Co., reminded the E. E. I. Convention that: "... there still obtrudes the impressive fact that about 70 per cent of the energy of the fuel is not converted into electricity." This loss is today accepted as inevitable, so much so that chipping off a per cent or two by high pressures and high temperatures is considered quite an achievement. A sizeable chunk was loosened by the use of binary vapor cycles but at a cost which still seems exorbitant.

It is just as inevitable that some day this impressive loss will be successfully attacked. Perhaps chemical cycles of some kind, perhaps new types of prime movers, perhaps by the direct conversion of fuel into electricity through some kind of an electrolytic cell. Verily, all the engineering problems have not been solved. The distance travelled toward perfection since the days of Watt is short compared to the distance yet remaining.

Courtesy G. E. Co.

Commonwealth Edison Co. is completing the first steps in a major modernization program for the granddaddy of all turbine stations. Two 375,000 lb. per hr., 1200 lb., 910 deg. F. boilers will supply a new 30,000 turbine which is topped on two old turbines to form an efficient and flexible 90,000-kw. cross compound unit supplying both the 25 and 60 cycle systems. Plans call for an increase in installed capacity of from 230,000- to 430,000-kw. with the same quantity of cooling water taken from the Chicago River

FISK'S NEW TOP PROGRAM

BACK in 1903, the power world was atwitter with expectancy for a great experiment was in the making. Chicago, the upstart of the West, was building a new central station. This in itself perhaps was commendable, but the new station at South Fisk Street and the Chicago River was to be the first all turbine central station and moreover the first unit was to be rated at 5000 kw.

Delegates to the N.E.L.A. Convention visited the partially completed station in a body[1] and unless human nature has changed greatly in 35 yr., handle bar mustaches waggled excitedly in entirely futile argument, for, nothing but operating results would tell whether it was a foolish pipe dream or a canny prognostication of the "Shape of the World to Come."

Monuments and History

The station was a success. It proved beyond a doubt the feasibility of large turbine units and sounded the death knell of the steam engine for central station service. More and bigger units followed. Before long the first unit, having served its purpose well, was taken back to Schenectady and set up as a perpetual monument (see photograph at top of this column), not alone to Chicago, but to the indomitable courage and foresight that has kept the American public utility industry continually in the forefront of world development.

Fisk Street Station grew. In 16 years the installed capacity was up to the full 230,000 kw. allowed by the available condenser cooling water. Other Chicago stations, Quarry, Northwest, Calumet and Crawford Avenue were built, but finally, limited cooling water and the spreading load forced the development of an integrated system covering 4000 sq. mi. and incorporating Waukegan, Powerton and State Line and other stations in outlying areas.[2] Each new station was a step forward, a living record of the development of an industry.

High pressure and temperatures came into service and with them the top plant, holding out to many obsolete plants a new lease on life. Fisk Street, located in a heavy load district, a strategic point in both the 25 and 60 cycle systems of the Commonwealth Edison Co., was an ideal set-up for a top plant and the first unit of the modernization program, two B. & W. 375,000 lb. per hr., 1200 lb., 910 deg. F. pulverized coal fired boilers and an Allis-Chalmers 30,000-kw. back pressure turbine, will soon be in operation. A second unit is planned and the ultimate development contemplates some 450,000 kw. of capacity with the same cooling water used for the original 230,000 kw. Even the name will be new. The volume on Fisk Street Station, the granddaddy of all turbine stations, has been closed. The new station, built within the 35 yr. old walls of the old, will be simple Fisk Station, a new name for a new era.

When modernization was started, the station consisted of 14 generating units installed over a period of years from 1906 to 1918, as the first four units, three 5000 and one 7500 kw., were replaced in 1908 and 1909 with larger machines. Of these 14, ten were 12,000 kw., 25 cycle 9 kv. vertical units operating at 200 lb. ga., 510 deg. F. Each turbine had eight 500 hp. B. & W. boilers fired by chain grate stokers. An operating gallery overlooked the turbine room. Auxiliaries were, in general, steam driven with the exhaust utilized in vertical closed heaters and deficiencies made up from a bleed connection to the turbine, a forerunner of the extraction cycle which did not become firmly established until a decade later, long after these units were forgotten.

The remaining four units were installed from 1914 to 1918. By the time the horizontal turbine had outdistanced the vertical, boiler practice had changed slightly and 60 cycle power had made surprising gains. Steam conditions were increased to 220 lb. ga., 550 deg, F., and although natural draft chain grate stokers were retained, the number of boilers per turbine was cut to

[1] See Fig. 3, p. 337 of the June 1937 issue.

[2] For a general review of stations of the Commonwealth Edison and the Chicago District systems see Power Plant Engineering, June 1937, p. 336 to 338.

four, the furnace width was increased from 10 ft. 10 in. to 24 ft. 7 in. and economizers were added. Nine of these 16 boilers were later changed to forced draft. All four turbines are of the horizontal type. No. 11, 25,000 kw., and No. 12, 35,000 kw., generate at 25 cycle, 9 kv., while No. 13, 30,000 kw. and No. 14, 20,000 kw., supply the 60 cycle, 12 kv. system. Each of these units was originally provided with one motor driven centrifugal circulating pump, one turbine and one motor driven hotwell pump. The condenser air removal equipment varied. Unit 11 had a kinetic system, Units 12 and 13 a hydraulic system and Unit 14 a dry air vacuum system.

Boilers for each of the 14 units are set in a row at right angles to the axis of the turbine room, odd and even rows facing each other so as to form a boiler aisle for each two turbine units. All coal cars are unloaded inside. For the first 10 units (5 aisles) the cars are dumped to hoppers at the end of the aisle and the coal delivered by V-bucket elevators to distributing V-bucket conveyors over the bunkers. In the newer section (2 aisles) cars are unloaded by clamshell buckets and the coal drops through crushers to two parallel V-bucket elevators which run transversely across the two boiler aisles, discharging to distributing belt conveyors.

After the last two units were installed the 60 cycle load continued to increase, and, to supply it from the 66 kv. transmission system interconnecting the several generating stations on the system, a large transformer installation totaling 340,000 kw-a. was made adjacent to the station and switching equipment for additional 60 cycle, 12 kv. lines provided.

By 1916 load and capacity requirements made necessary the installation of a 40,000-kw. frequency charger and the first portion of a 66 kv. transmission terminal. Switchboard equipment for these new developments could not be accommodated in the old galleries (one for units 1 to 7 and another for units 8 and 14) which were small and in the passage of the years had become overcrowded. It was, therefore, necessary to install and operate a third control center for the added equipment, designed on a temporary basis because a consolidated gallery was contemplated. Expansion of facilities at the station, including a second 40,000-kv-a. frequency changer and 66-kv. transformers, was so rapid and the development of the steam end so uncertain that this was deferred from year to year and the temporary center extended.

During the past few years the future development of the station has been studied and its general trend determined with the results that three important and interrelated modernization projects were undertaken. The projects are: Installation of a new and modern control center, which consolidates and replaces the three separate operating galleries; modernization of a portion of the turbine and boiler plant by the installation of a high pressure turbo-generator and boilers; and a rearrangement and modernization of the auxiliary power supply system.

The control center project has just been completed. In laying out the new gallery, the desirability of overlooking the turbine room was reluctantly waived and a space conveniently located with respect to existing control conduit runs was made available by clearing a portion of the upper floor of the old 25 cycle switchhouse. Extensive building changes were not required, but because walls and ceiling were needed for conduits and wiring, the operating area was deprived of outdoor windows and skylights so a complete air conditioning system was provided.

As one purpose of the new center was reduction in operating expenses, the main control panels were arranged in a double row facing each other, with a twelve-foot operating aisle between. Equipment on these panels was reduced to the minimum required and small-sized instruments were used for compactness. Flexible bronze armored multiple-conductor cables were generally used

INCREASES CAPACITY 30,000 Kw.

Fig. 2. The new control center replaces three separate galleries and is completely air conditioned. The synchroscopes in the upper foreground are of the recording type

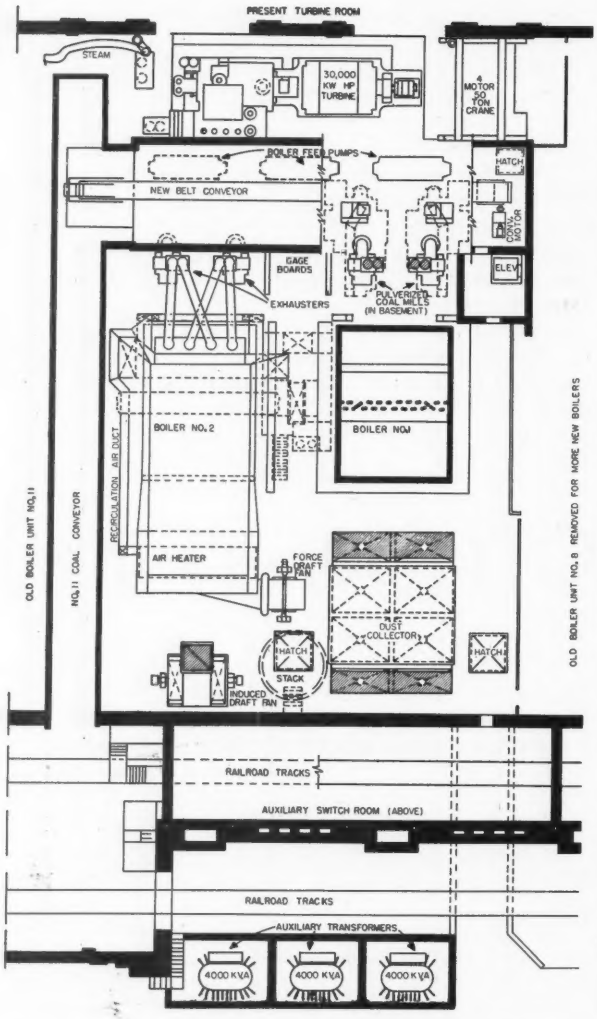

Fig. 3. Plan of the operating floor of the new high pressure section. Two 1200 lb., 910 deg. F., 375,000 lb. per hr. boilers, 30,000-kw. turbine No. 15 and the three feed pumps are installed in space formerly occupied by the 16 old boilers which supplied Units No. 9 and 10. The relative location of the old and new equipment is shown by Fig. 4. The left hand side is a plan of Section A-A of Fig. 5 and the right hand a plan of Section B-B

for short runs; varnished cambric wires were adopted for wiring on the panels; instruments were flush mounted on No. 10 gage steel panels,[3] most of which are in single sheets 4 ft. 3 in. by 8 ft. 3 in. It was found possible to eliminate glare on the Weston indicating instruments by special scale covers with the glass set at an angle so that the upper edge is farther from the panel than the lower edge.

Inasmuch as the modernization plan contemplates the eventual removal of Units 1 to 10 (which are still in peak and emergency service) and the topping of Units 11 to 14, the 16 boilers for the latter have been retained for low pressure operation. Boilers for Units 10 and 9 were removed to provide space for two new boilers, auxiliaries and the new 30,000-kw. top turbine, No. 15. As shown by the plan, Figs. 3 and 4, and cross section, Fig. 5, this new equipment is included within the space formerly occupied by the two rows of eight boilers, with no building changes other than raising the roof.

The new turbine is in the boiler room adjacent to the turbine room partition. The boilers face the turbine with boiler feed pumps, coal scales and exhauster fans between on the operating floor. The four pulverizers are located in the basement. Gases pass upward through the single pass boiler reverse and flow downward through tubular air heaters, horizontally through electrostatic precipitators and upward to induced draft fans which discharge through a short breeching to the stack.

This stack, 219 ft. 9 in. high above the supporting steel work and 13 ft. 10 in. in diam., serves both boilers. It is of all welded construction and is lined with paving brick.[4] The fan floor with the forced and induced draft fans and air heaters is behind the boiler about 29 ft. above the operating floor. Air from the forced draft fans travels upward through the air heater to a wide flat duct which passes over the top of the boiler and then splits, the two branches dropping vertically to opposite ends of the burner windbox. Heated air for pulverizer drying, taken from the windbox, is tempered with cold air from a duct running back to the discharge of the forced draft fan.

Coal is brought to the new boilers by a belt conveyor fed from the existing conveyor for No. 11 boiler aisle. The coal bunker for each new boiler holds six hundred t. and the coal feeds from these by gravity through Richardson coal scales and table type feeders.

These mills, two for each boiler, each mill supplying two burners, are the new Foster Wheeler double classifier type, each with 15 t. capacity. Raw coal is fed at one end through a rotating table type feeder controlled so as to maintain a constant level in the mill. Preheated air enters each end through hollow sleeves supported at the center of hollow trunnion bearings. The air with the entrained pulverized coal passes out through spaces between the sleeves and trunnion walls, to classifiers at each end of the mill and through a Y connection to the exhauster fans on the floor above, to the burners. Fuel to the furnaces is controlled by a damper in the exhauster suction.

[3]See A New Method of Wiring Panels and Equipment by A. E. Anderson, Power Plant Engineering, May 1937, p. 289.

[4]For a detailed description of the stack see Power Plant Engineering, p. 553, Sept. 1937.

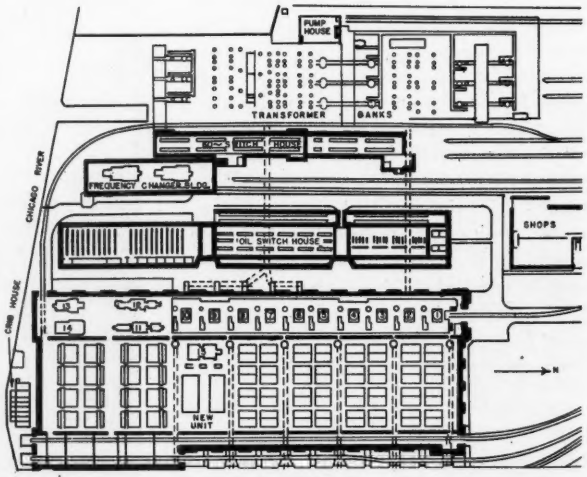

Fig. 4. Plot of Fisk Station and grounds. The general arrangement of old and new equipment are visible

Approximate division of heating surface and heat absorption of the new boilers

Section	Heating Surface	Heat Absorption
Furnace	5,070 sq. ft.	42%
Boiler	6,640 " "	12%
Superheater	19,800 " "	25%
Economizer	12,000 " "	13.5%
Air Heater	56,200 " "	7.5%
Total		100.0%

Boilers are unusually interesting and have the so-called two stage furnace, the first section for continuous slag tap through two openings in the floor, the second stage for dry ash removal. Both sections are completely water cooled. In the first section stud-tubes covered with KN plastic refractory are used throughout so that there is no bare wall surface. Fuel is fired downward and the gases pass through a screen into the second stage where combustion is completed. This screen is made by staggering alternate pairs of tubes, as shown by the boiler plan and section, Figs. 3 and 5. These pairs of stud tubes, covered with refractory, form a complete screen and the second stage of the furnace cannot see the first stage, the gases being forced to make two complete right angle turns in getting through. Three sides of the second stage furnace are made of 3¼ in. bare tubes on 6 in. centers. The sloping hopper bottom is covered with flat blocks and the front wall is formed by the covered backs of the stud tube screen.

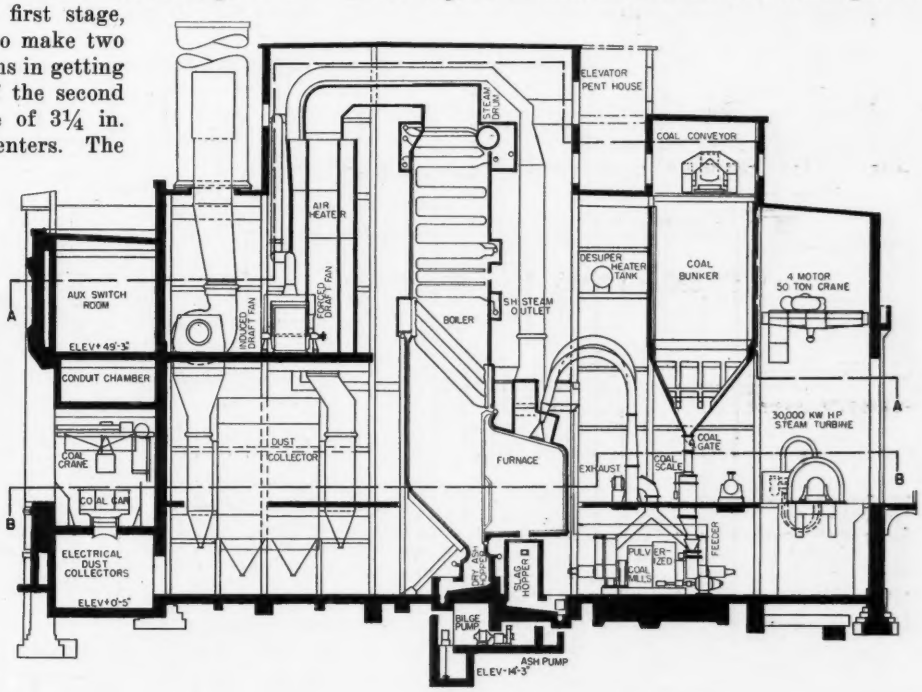

Fig. 5. Section through the new boiler room. Each boiler is fired by two ball mills each supplying two burners. Electrostatic precipitators preceding the induced draft fan removes dust and fly ash

Both the economizer and superheater sections are directly above the boiler proper, and divided by a vertical baffle to give controlled gas flow for superheat regulation. Gas flow dampers are located in a horizontal flat duct passing back to the top of the air heater. Air recirculation from windbox to air heater is provided by a duct visible on Fig. 3. Air heaters, forced and induced draft fans and electrostatic dust collectors are grouped back of the boilers as shown by the cross section. This compact arrangement is made possible largely by the arrangement of the hot air duct over the top of the boiler as explained earlier.

Each of the two boilers has a continuous steaming capacity of 375,000 and a peak of 412,500 lb. per hr., the heating surfaces and approximate heat absorption of each section being shown by the accompanying table. This emphasizes the relatively unimportant position occupied by the boiler section proper in a modern steam generator. Steam will be supplied to the header at 1225 lb. ga., 910 deg. F.

Furnace heat release at normal load will be 31,600 B.t.u. per cu. ft. and the overall efficiency of the complete unit about 86 per cent. The furnace water tubes are backed by plastic cement and magnesia block insulation and the entire unit will be enclosed by a welded steel jacket.

One Sturtevant forced draft fan, with vane control and a maximum capacity of 128,000 c.f.m. at 140 deg. F. and 9.7 in. of water, is provided for each boiler. This is located on the fan floor at the base of the air heater and is driven by a constant speed 350-hp., 1185 r.p.m. Westinghouse motor. The Sturtevant induced draft fan, one per boiler, located directly behind the respective boilers, has a maximum capacity of 222,000 c.f.m. at 400 deg. F. and 16.0 in. and has two Westinghouse driving motors, a 900-hp., 890 r.p.m. motor for maximum capacity and a 500-hp., 709 r.p.m. motor for normal load. The Cottrell precipitator is located on the suction side of the fan to reduce wear on the fan rotor due to dust.

Three Worthington boiler feed pumps with a capacity of 1000 g.p.m. each at 1600 sq. in., are located on the operating floor. Each pump is driven by a 1135-hp., 3500 r.p.m. turbine which uses high pressure steam and exhausts to the low pressure or cross over system in parallel with the main turbine as shown by the heat balance, Fig. 6.

The 1500 r.p.m. Allis-Chalmers high pressure turbine has one impulse and 28 reaction stages and drives a 30,000-kw., 0.95 p.f., 25 cycle 9 kv. generator. Indications are that the 25 cycle load will remain fairly constant for many years and for this reason the new

turbine will in normal operation be superposed on No. 11, 25,000 kw. and No. 12, 35,000 kw. making a highly efficient 90,000-kw. cross compound unit with a calculated heat rate, as shown by the heat balance, of about 12,150 B.t.u. per kw-hr.

As the new turbine exhausts to the low pressure system and can be paralleled with the low pressure boilers, the arrangement is flexible and the exhaust may, if desired, be utilized in the 60 cycle units No. 13 and 14. The new turbine is also designed so that the speed may be increased to 1800 if necessary in the future to accommodate a 60 cycle generator.

Control of high-pressure, high-temperature top plants of large size involves problems unknown in earlier installations, hence the practice in this station represents a distinct advance in the control art. The Smoot automatic controls for combustion, feedwater excess pressure and boiler water level, together with the pressure-reducing and desuperheating by-pass station, are designed to give the flexibility necessary for operating a station of this size under either automatic or manual control, the entire operation coordinated

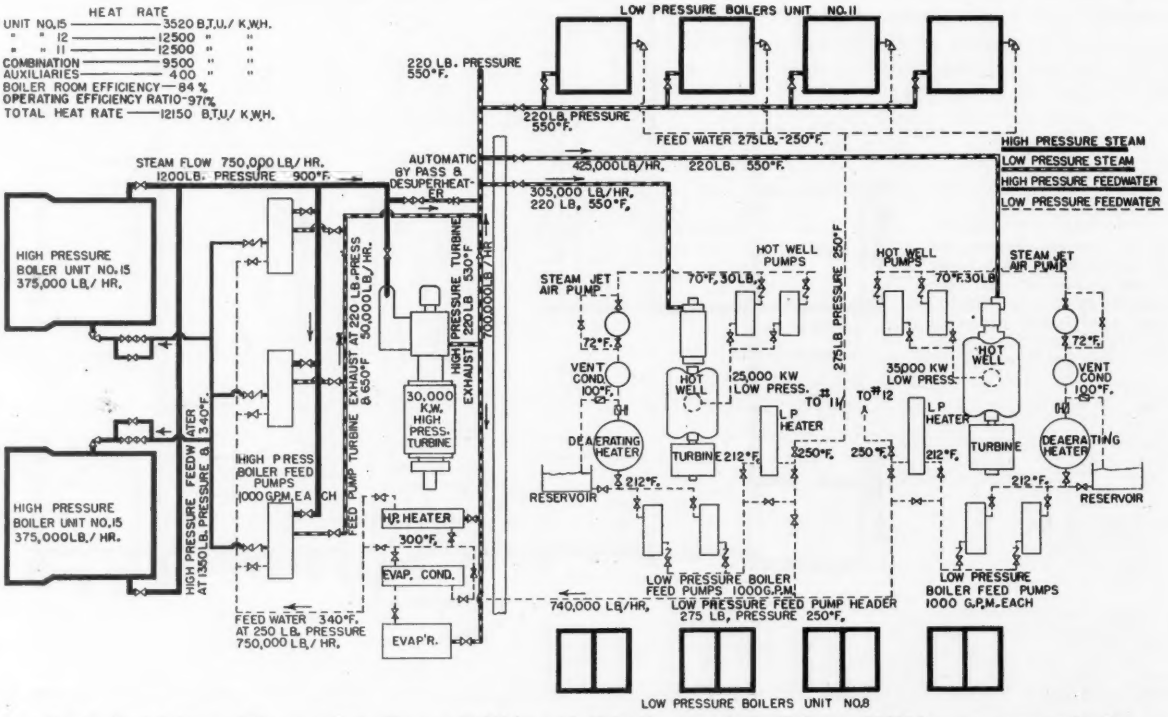
HEAT RATE
UNIT NO.15 — 3520 B.T.U./ K.W.H.
" " 12 — 12500 " "
" " 11 — 12500 " "
COMBINATION — 9500 " "
AUXILIARIES — 400 " "
BOILER ROOM EFFICIENCY — 84 %
OPERATING EFFICIENCY RATIO-97%
TOTAL HEAT RATE — 12150 B.T.U./ K.W.H.
LOW PRESSURE BOILERS UNIT NO.11
220 LB. PRESSURE 550°F.
220LB. PRESSURE 550°F.
FEED WATER 275LB.-250°F.
HIGH PRESSURE STEAM
LOW PRESSURE STEAM
HIGH PRESSURE FEEDWATER
LOW PRESSURE FEEDWATER
STEAM FLOW 750,000 LB./ HR. 1200LB. PRESSURE 900°F.
AUTOMATIC BY PASS & DESUPERHEATER
425,000LB/HR. 220LB. 550°F.
305,000 LB./HR. 220 LB. 550°F.
HIGH PRESSURE BOILER UNIT NO.15 375,000 LB./ HR.
HIGH PRESSURE BOILER UNIT NO.15 375,000LB./ HR.
HIGH PRESS. FEEDWATER AT 1350LB. PRESSURE & 340°F.
EXHAUST AT 220 LB. PRESS & 650°F 50,000LB./HR.
HIGH PRESSURE TURBINE EXHAUST 220 LB 530°F 700,000 LB./HR.
30,000 K.W. HIGH PRESS. TURBINE
HIGH PRESS BOILER FEED PUMPS 1000 G.P.M. EACH
FEED PUMP TURBINE
H.P. HEATER 300°F.
EVAP. COND.
EVAP'R.
FEED WATER 340°F. AT 250 LB. PRESSURE 750,000 LB./ HR.
HOT WELL PUMPS
70°F. 30LB.
STEAM JET AIR PUMP
72°F.
VENT COND. 100°F.
HOT WELL
25,000 KW LOW PRESS.
TO 11
LP HEATER
DEAERATING HEATER
212°F.
TURBINE
250°F.
RESERVOIR
275LB. PRESSURE 250°F.
35000 KW LOW PRESS.
TO 12
LOW PRESSURE BOILER FEED PUMPS 1000G.P.M.
740,000 LB/HR. LOW PRESSURE FEED PUMP HEADER 275 LB. PRESSURE 250°F.
LOW PRESSURE BOILER FEED PUMPS 1000 G.P.M. EACH
LOW PRESSURE BOILERS UNIT NO.8

Fig. 6. Heat balance of the new plant. The new 30,000-kw. wi h Units No. 11 and 12 will form a 90,000-kw. cross compound unit

either through direct interconnection of the controls or indirectly through the controlled equipment.

This automatic combustion control involves the usual master controller responsive to steam header pressure, with one master and two boiler master panels. In addition to master loading indicators for each boiler and provision for changing from automatic to manual operation, the master panel has a feed pump control sub-panel for regulating the pumps automatically or manually to give excess pressure in accordance with load changes, although the feedwater flow to each boiler is under the final control of a separate water level regulator actuated from the water level in the drum.

Each boiler panel, centralizing the control for that boiler, carries the fuel and air master loading indicators and fuel-air ratio adjusters of the boiler master, controls for dividing pulverizing mill load, maximum load limitators, transfer lever for changing the boiler from automatic to manual operation, and, in addition, a newly developed Smoot feature that gives independent remote hand control from the boiler panel of any individual regulator. These regulators, four of the six on each boiler unit, control the combustion air supply from the forced draft fan, the combustion gas flow through the boiler produced by the induced draft fan and the coal feed to the furnace (one regulator for each mill). The other two regulators control mill suction but are not equipped for remote hand control.

Coal from the feeder to each mill is regulated from the mill coal level by equipment supplied with the mills and separate from the combustion control system proper. Pulverized fuel feed to the burners is governed by the combustion control through dampers in the inlet to each exhauster. Primary mill air is proportioned according to load so as to maintain a negative pressure in the mill at all times. Secondary air to the furnace is controlled in accordance with furnace pressure while the air and combustion gas flow is controlled by the draft drop across the gas side of the air heater.

The pressure reducing and desuperheating by-pass station, so important in a top plant to supply the high-pressure steam to the low-pressure system through the cross-over in case the high-pressure turbine cuts out suddenly or is out of service temporarily, is unusually interesting. Because of the need for shutoff, quick-opening and regulating characteristics at such a large capacity, (750,000 lb. per hr. continuous or 825,000 maximum), two valves are used. One is a quick-opening stop valve, which is normally closed but which opens

PRINCIPAL EQUIPMENT FOR NEW UNIT AT FISK STATION

GENERAL:
Owner: Commonwealth Edison Co.
Location: Chicago, Ill.
Engineers: Sargent & Lundy, Inc.

STEAM GENERATING UNITS—Babcock & Wilcox Co.—Two units, each with a continuous capacity of 375,000 and a maximum capacity of 412,500 lb. per hr. of steam at 1275 lb. per sq. in. ga., 910 deg. F. at the superheater outlet. They are of the sectional water tube type with two stage water cooled furnaces (steel tube, bare tube and flat block); continuous tube steaming economizers; continuous tube counterflow superheaters; and welded vertical tubular air heaters. Furnace width 23 ft., depth 30 ft., average height in primary section, 18 ft., in secondary section, 28 ft. Heat liberation 31,600 B.t.u. per cu. ft. per hr. Continuous slag tap from primary furnace through two holes in the floor. Dry ash removal from secondary furnace. Each furnace fired by pulverized coal through four multiple intertube burners with an electrically lighted illuminating gas ignition system.

Boiler heating surface.....6640 sq. ft.
Economizer heating surface.....
.....12,000 sq. ft.
Water Wall surface
Primary furnace .....1760 sq. ft.
Secondary furnace .....1870 sq. ft.
Slag screen ..... 950 sq. ft.
Air Heater surface.....56,200 sq. ft.
Furnace volume
Primary furnace .....7000 cu. ft.
Secondary furnace .....9700 cu. ft.

PULVERIZERS—Foster Wheeler Corp.—Four Type D-5 ball mills with a capacity of 15 t. per hr., at 70 per cent through 200 mesh. Each mill driven by a 300 hp., 2300 v., 60 cycle, 450 r.p.m. motor through herringbone gears. Each mill complete with a size 53 exhauster with capacity of 17,500 c.f.m. of 150 deg. F. air at 8 in. of water and driven by a 125 hp., 2300 v., 60 cycle, 1200 r.p.m. motor. Feeders of the rotating table type controlled from the coal levels in the mills.

COAL SCALES—Richardson Scale Co.—Four units of the automatic apron feed type with capacity of 16 to 20 t. per hr. each.

COAL HANDLING EQUIPMENT—Link Belt Co.—42 in. belt conveyor taking coal from present handling system for delivery to new bunker. Belt speed 250 ft. per min., capacity 350 t. per hr.

FORCED DRAFT FANS—B. F. Sturtevant Co.—Two Turbovane fans with vane control each with a maximum capacity 128,000 c.f.m. of 140 deg. F. air at 9.7-in. of water. Each fan driven by a 350 hp. Westinghouse, 2300 v., 60 cycle, 1160 r.p.m. motor.

INDUCED DRAFT FANS—B. F. Sturtevant Co.—Two Turbovane fans with damper control each with a maximum capacity of 222,000 c.f.m. of 400 deg. F. gas at 16 in. of water. Each fan driven by 2 Westinghouse 2300-v. motors, a 900 hp., 890 r.p.m. motor for maximum capacity and a 500 hp., 709 r.p.m. motor for normal capacity.

SOOT BLOWERS — Diamond Power Specialty Corp.—Eight telescopic units and 28 Valve-In-Head units per boiler.

DUST COLLECTORS—Research Corp.—Two Cottrell electrostatic precipitators. Expected recovery at normal capacity 180,000 c.f.m. (each) of 360 deg., gas, 90 per cent.

DUST HANDLING SYSTEM—United Conveyor Corp., pneumatic system with capacity of 10 t. per hr.

SLAG AND ASH HANDLING SYSTEM—Allen-Sherman-Hoff Co. Hydrojet system with ash and slag pumped to the present ash storage in the yard by two Type CI Hydroseal 1750 r.p.m. 8 in. motor driven ash pumps.

ASH AND SLAG HOPPERS—Henry Pratt Co.

STACK—Henry Pratt Co. welded steel 13 ft. I.D. 300 ft. above datum with a 4 in. vitrified brick lining. This company also supplied the breeching and air ducts.

BLOW OFF VALVES—The Edward Valve & Mfg. Co., for boiler, water wall and economizer.

STOP, CHECK, NON-RETURN, BACK PRESSURE VALVES—The Edward Valve & Mfg. Co.

LARGE VALVES—Crane Co. and The Edward Valve & Mfg. Co.

AUTOMATIC COMBUSTION CONTROL—Republic Flow Meters Co.—Smoot system complete with panels.

FEED WATER REGULATORS—Republic Flow Meters Co.—Smoot Boiler water level control.

EXCESS PRESSURE PUMP CONTROL—Republic Flow Meters Co.—Smoot.

PRESSURE REDUCING AND DESUPERHEATING EQUIPMENT—Republic Flow Meters Co.—Smoot. normal capacity 750,000 lb. per hr. of steam reduced from 1200 lb., 900 deg. F. to 220 lb., 525 deg. F.

WATER COLUMNS — Diamond Power Specialty Co.—Bicolor.

FEEDWATER TREATMENT—The Permutit Co.—Zeolite (with acid) pretreatment for evaporator feed taken from the South Branch of the Chicago river and with Monsanto Chemical Co. Santosite supplementary feed.

EVAPORATING PLANT—Griscom-Russell Co.—Two Style J horizontal submerged Bentube evaporators with maximum capacity of 27,000 lb. per hr., distilled water each. Vapor from both units passes to a single evaporator condenser of the horizontal floating head type with 1151 sq. ft. of surface.

HIGH PRESSURE CLOSED HEATER — Griscom-Russell Co. — Style SSJ horizontal floating head type with a surface of 635 sq. ft.

BOILER FEED PUMPS—Worthington Pump & Machinery Corp.—Three Type WCS, 6 in., 6 stage centrifugals, each with a capacity of 11,000 g.p.m. at suction pressure 275 lb. and discharge pressure 1600 lb. When driven by a 3500 r.p.m. Westinghouse 1135 hp., turbine using steam at 1200 lb., 900 deg. F. and exhausting to the low pressure system.

PIPING—Midwest Piping & Supply Co., Inc.—Complete installation for the two boilers, the new turbine, auxiliaries and appurtenances. 1500 lb. seamless tubing supplied by National Tube Co., and fabricated by Crane Co.

INSULATION—Johns-Manville.—High temperature and 85 per cent magnesia for pipes, ducts and boilers.

TURBO-GENERATOR — Allis-Chalmers Mfg. Co.—One 30,000 kw., 1500 r.p.m. turbine operating at throttle conditions of 1200 lb. gage, 900 deg. F., exhausting to the low pressure system to give a 90,000 kw. cross compound unit with present Units No. 11 and 12. Turbine drives a 9250 v., 25 cycle, 3 phase, 95 per cent power factor generator, a 110-kw., 250 v. main exciter and 5-kw. pilot exciter.

GENERATOR AIR COOLER—Griscom-Russell Co.—Capacity 2,202,241 B.t.u. per hr., water flow 292 g.p.m., air flow 55,000 c.f.m., cooled from 143.8 to 104 deg. F.

TURBINE CRANE—Northern Engineering Works.—Span 19 ft. 7 in., lift 36 ft. 9 in., main hoist 50 t., auxiliary hoist 10 t.

AUXILIARY TRANSFORMERS—General Electric Co.—Three 4000 kv-a., 12,000/2300/440.

AUXILIARY SWITCHROOM CUBICLES—Allis-Chalmers Mfg. Co., in the 2300-v., and General Electric Co. in the 440-v room.

MINIATURE CONTROL BOARD INSTRUMENTS—Weston Electrical Instrument Co.

BILGE PUMPS—Yeomans Bros. Co.—Two vertical centrifugals with capacity of 1000 g.p.m. each against 40 ft. head, motor driven at 1170 r.p.m.

EVAPORATOR FEED PUMPS—Yeomans Bros. Co.—Two centrifugals with capacity of 60 g.p.m. each against 75 ft. head, motor driven at 3500 r.p.m.

SLUICE WATER SUPPLY PUMPS—Ingersoll-Rand Co.—Two centrifugals with capacity of 1000 g.p.m. each against 100 lb. pressure, motor driven at 1800 r.p.m.

EVAPORATOR CONDENSER DRAIN PUMPS—Worthington Pump & Machinery Corp.—Two 4 stage centrifugals with capacity of 125 g.p.m. each against 285 lb. pressure, motor driven at 3550 r.p.m.

AIR AND COOLER PUMPS—Yeomans Bros. Co.—Two centrifugals with capacity of 350 g.p.m. each against 25-ft. head, motor driven at 1750 r.p.m.

GLAND WATER PUMPS—Weil Pump Co.—Two centrifugals with capacity of 75 g.p.m. each, motor driven at 3450 r.p.m.

ELEVATORS — Westinghouse Electric & Mfg. Co.

SMOKE INDICATORS—T. W. McNeill Engineering & Equipment Co.—Two Eclipse photoelectric type indicators and alarm systems.

CONTROL ROOM PANELS—General Electric Co.

CONTROL ROOM RECORDING INSTRUMENTS—The Bristol Co.—Five temperature recorders; Leeds & Northrup Co., 6 temperature recorders and 6 frequency recorders; Westinghouse Elec. & Mfg. Co., 2 wattmeters.

automatically if the cross-over pressure drops below a predetermined value. The other is the regulating valve which controls the flow. When the high-pressure turbine is under back-pressure governing, the usual operating condition, the regulating valve floats in a position corresponding to the steam flow through the turbine. The control mechanism of this valve knows what is happening in the turbine, so that if the turbine is cut out suddenly, the quick-opening valve opens wide and the regulating valve is already in position to handle the flow of steam that comes to it. When the turbine is on speed control, provision is made for "synchronizing" both back-pressure turbine governor and regulating valve before the turbine is returned to back-pressure control in case the turbine load has changed under speed control. Water for desuperheating is supplied from a constant level tank in such a way that the water flows to the desuperheater nozzle automatically under control of the steam flow itself and in proportion to the steam flow.

All 1500 lb. standard high pressure steam piping is of carbon-molybdenum steel with welded joints except at the machinery connections which have to be broken periodically for inspection and overhauling. Valves have alloy-steel bodies, stainless steel trim and Stellited seats and disc faces.

Heat Balance

Details of the steam and water flow are shown on the flow diagram. The heat rate of the new machine is 3520 B.t.u. per kw-hr. against 12,500 B.t.u. for units No. 11 and 12. This gives a combined rate of 9500, or, with an allowance of 400 B.t.u. for auxiliaries, a gross of 9900. Assuming a boiler efficiency of 84 per cent and an operating efficiency ratio of 97 per cent, the overall heat rate figures out as 12,150 B.t.u. per net kw-hr.

Units No. 11 and 12 were originally provided for two stages of extraction for the deaerating and one closed heater as shown on the heat balance. It was found possible to add another extraction point to No. 12 by inserting a ring inside the turbine casing and taking the connection out through the shell to supply the high pressure heater in the high pressure boiler feed system.

Electrical connections for the new unit are simple, and did not involve a great deal of new construction or change of existing structures or practice beyond the use of two reactors and an isolating breaker. Auxiliary electrical changes were more extensive and form the basis of the auxiliary part of the modernization program.

On the old vertical units direct current was used. When units 11 and 14 were installed in 1914 a change was made to 220 v., 25 cycle and in 1918 when units 12 and 13 were installed, 440 v., 25 cycle was used. For the new unit it seemed desirable to comply with the company's latest practice and use 60 cycle current for the entire station, 2300 v. for motors of 150 hp. and larger and 440 v. for those smaller.

For this reason the 220-v. motors on the old auxiliaries were entirely replaced. Some of the 440 v. motors were replaced and some rewound. The speed change from 25 to 60 cycle involved no mechanical difficulty beyond cutting down some of the pump and fan rotors. This made it possible to abandon the 220-v. switching center and concentrate all auxiliary power supply by two new centers, one for 440 v. in the basement and one for 2300 v. in a gallery on the fan floor back of the new boilers.

Auxiliary power is taken from 12 kv. buses through three 4000 kv-a., 3 ph. transformers connected, as shown by Fig. 8, to three different systems. Each transformer has two secondary windings, 3500 kv-a. at 2300 v. and 500 kv-a. at 440 v. The fault bus protection usual in Commonwealth Edison practice was, due to local conditions, replaced by differential relays. Auxiliary buses are sectionalized, one side normally supplied by transformer No. 1 and the other by transformer No. 3 as shown by Fig. 8. Transformer No. 3 is a spare automatically connected to either side upon loss of the normal power supply. The system is ungrounded and a grounded phase is indicated by lamps in the 440 and voltmeters on the 2300 v. auxiliary switch room.

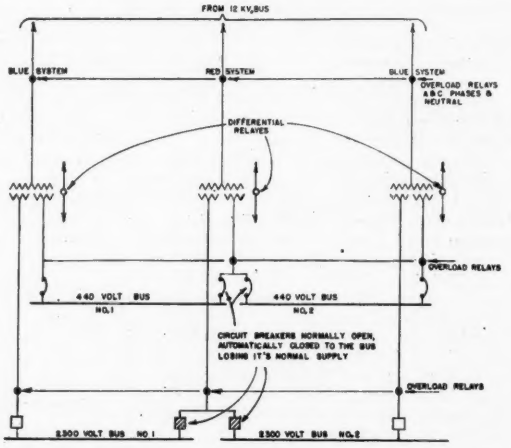
FROM 12 KV BUS
BLUE SYSTEM
RED SYSTEM
BLUE SYSTEM
OVERLOAD RELAYS A B C PHASES & NEUTRAL
DIFFERENTIAL RELAYS
OVERLOAD RELAYS
440 VOLT BUS NO.1
440 VOLT BUS NO.2
CIRCUIT BREAKERS NORMALLY OPEN, AUTOMATICALLY CLOSED TO THE BUS LOSING IT'S NORMAL SUPPLY
OVERLOAD RELAYS
2300 VOLT BUS NO.1
2300 VOLT BUS NO.2

Fig. 8. Single line diagram of the auxiliary power supply. Both 440 and 2300 v. buses are supplied from separate windings on the same transformers

General Electric cubicles are used in the 440 v. center and Allis-Chalmers in the 1300 v. center. Both individual and grouped control of motors is provided with remote control from the motor or manual control in the power center. In general auxiliaries for one boiler are carried from one bus and those of the second boiler from the other bus.

Modernization work has been coordinated with plans for future new units that will be added as load conditions indicate, and will result in a modern station on the original site with a minimum amount of building changes. Large investment in condenser water tunnels, coal handling tracks, underground conduit and cable that would otherwise be lost if a new station were to be built in another location are retained in useful service.

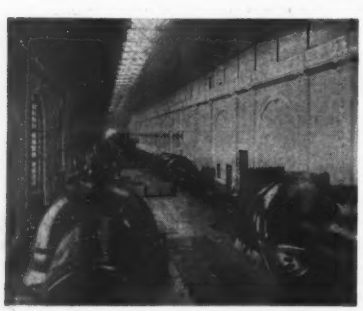

Fig. 7. General view of the old station with Units No. 11 to 14 in the foreground. These will be retained in the modernized plant but the old vertical Units No. 1 to 10 will eventually be removed

Detecting Condenser Leakage

Alarm system developed in Detroit Edison Co. plant meets the need for a practical device to prevent feedwater contamination by condenser leakage

R. J. McCAUSEY,

Research Department
The Detroit Edison Co.
Detroit, Michigan

PREVENTION OF boiler feedwater contamination due to condenser leakage, makes it desirable to have a leakage alarm easily adjustable within a narrow range of condensate conductivities. An alarm so adjustable need not be compensated for seasonal variations in condensate temperature, as the alarm may be set to signal at a higher conductivity for summer operation than is necessary for winter. The device described in this article is designed to be quickly adjusted to signal at any conductivity in the range 2 to 6 micromhos per cm^3. Principle of operation is a variation of the ammeter method of measuring the electrical conductivity of aqueous solutions and differs from similar devices, previously described only in the selection of the parts, which are believed to have sufficient advantages to justify their use.

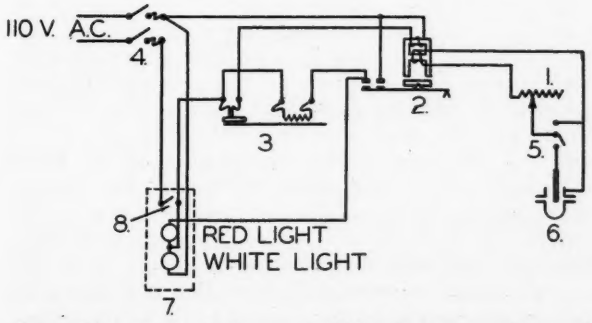

Fig. 1. Schematic circuit diagram. 1, 50,000 ohm, 15 ma., wire wound rheostat. 2, 110 v. a.c. primary, 440 v. secondary transformer relay* with contacts normally open. 3, thermostatic mercury circuit breaker with 110 v. a.c. heater. 4, 5 and 8, 250 v., 3 amp. toggle switches. 6, flow type conductivity cell. 7, remote signal lamp and switch box

* The transformer relay used and shown by the drawing Fig. 1 and the photograph, Fig. 4, is an induction relay, a device which has found wide application in industry for such varied service as floatless pump control, water level control in tanks and boilers, low water cut out, in fact, for any operation where an electrode may be short circuited for control purposes.

The relay is built in the form of a three legged transformer with the lower leg movable, or perhaps more correctly, the core is A shaped with the primary, connected directly to the alternating current supply, wound on the top leg and the secondary wound on the middle leg. What would be the bottom leg of a three legged transformer, forms the armature and carries the electrical contacts. This armature normally hangs down so as to leave an air gap between it and the legs of the core. The secondary is normally open and due to the reluctance of the air gap the flux path is through the rectangle formed by the top and bottom leg and the top portion of the legs. When the secondary circuit is closed, this flux distribution is disturbed and the added flux through the lower legs of the core attracts the armature. The armature in moving to close the air gap operates electrical contacts. These contacts may be arranged normally open or normally closed to meet the needs of the specific application.

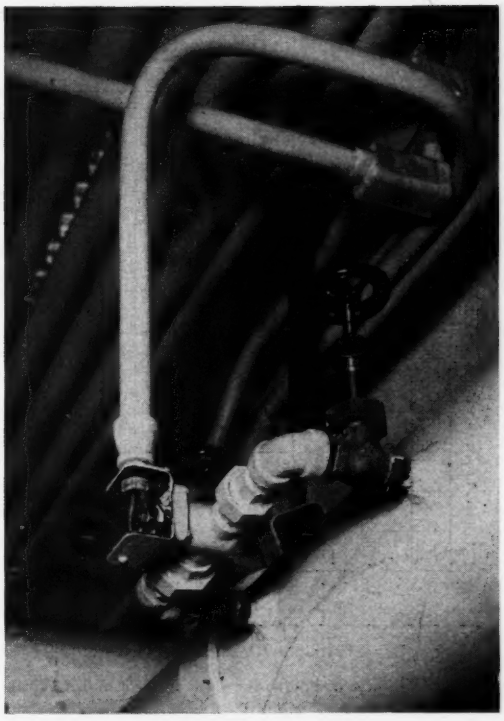

Fig. 2. Conductivity cell installed on condensate piping

The device consists essentially of a conductivity cell, a transformer-relay*, a thermostatic circuit breaker and a rheostat. These parts together with the necessary accessories are used in the schematic-diagrammatic circuit shown in Fig. 1. Some of them are described in more detail in the following paragraphs. The flow type conductivity cell has a gold-plated brass electrode, and an Isolantite (ceramic) insulator mounted on a cast brass cell body. It is designed for external mounting on pipe lines or in a by-pass on pipe lines as shown in Fig. 2. Flow through the cell, in this case, is induced by piping provisions utilizing the velocity head of the water.

Inasmuch as it is a combination relay and transformer, the transformer-relay* used is unusual. When excited with 110 v. a.c. the secondary potential is about 440 v. and the secondary current necessary to cause operation is proportionately lowered. The low cell currents are desirable to minimize polarization and deterioration. The relay may be set to operate with a resistance as high as 45,000 ohms in series with the secondary coil. Under these conditions a ten per cent change in exciting voltage causes less than a five per cent change in the maximum external secondary resistance permitting operation. Hereafter, the maximum external secondary resistance permitting relay operation will be referred to as the relay "operating resistance".

The thermostatic circuit breaker, a bi-metallic element carrying a mercury switch and a low wattage heating element, is connected in the circuit (Fig. 1) to periodically interrupt the primary circuit when the relay operates to give an alarm. The relay armature "freezes" upon operating, thus requiring the circuit breaker to cause the device to cease signalling when

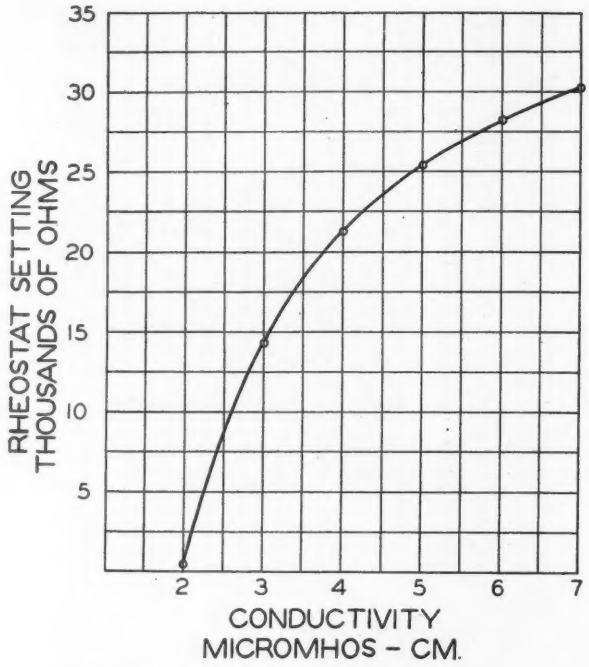

Fig. 3. Calibration curve computed for a cell constant of 0.083 reciprocal cm. and a relay operating resistance of 42,000 ohms

the condensate conductivity has fallen below the value set to give an alarm.

In the secondary circuit the rheostat provides the means of adjusting the device to give an alarm at a desired conductivity. Switched across the relay secondary coil by means of switch 5, Fig. 1, it becomes a means of determining the relay operating resistance when the adjusting knob is slowly rotated in the direction to decrease the resistance until the relay closes.

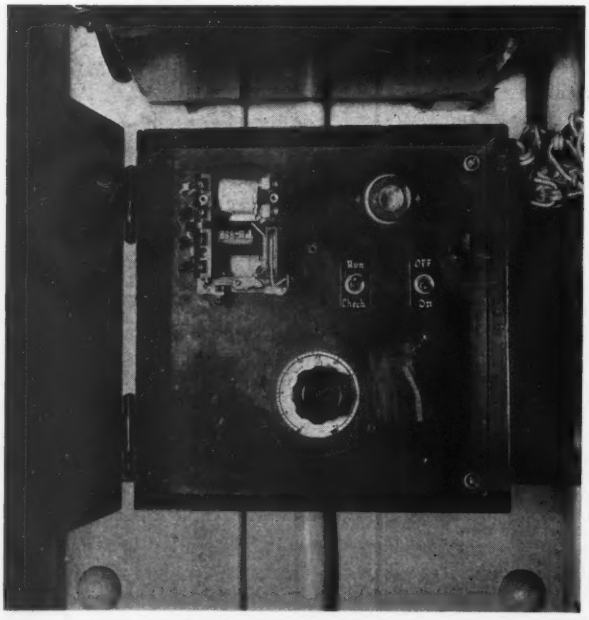

Fig. 4. Condenser leakage alarm assembled in the cabinet. The transformer relay, 2 of Fig. 1, is shown in the upper left hand corner of the cabinet

Calibration of this device may be plotted as a curve representing rheostat setting values in ohms vs. conductivity values in micromhos-cm. The calibration is determined as follows: From the cell constant the conductance is computed for any given specific conductivity. The resistance of the cell being the reciprocal of the conductance this value is readily obtainable. Then the rheostat setting for any conductivity at which the alarm is to operate is the relay operating resistance less the resistance of the cell. A typical calibration curve appears as Fig. 3.

Determination of the cell constant can be most conveniently made after the cell is placed in service and was found to be sufficiently accurate when computed from simultaneous cell conductance and condensate conductivity measurements, made when conductivity and temperature varied slowly. The experimental model of this device shown by the photograph in Fig. 4, together with the conductivity cell illustrated in Fig. 2 has been in service for over a year with no serious indication of deterioration or change in calibration.

Caking and Coking Tests

VARIOUS EMPIRICAL laboratory tests have been proposed and used as measures of coking and caking properties of coals in connection with their selection for coke making and their use as fuel when burned on grates. One such test, designated as the agglutinating value test, has received much study by fuel technologists in this country and abroad. In this test, caking characteristics of a given coal are measured by the crushing strength of a carbonized mixture of the coal with an inert material serving as a diluent. This gives an approximate measure of the material in coal which melts and becomes plastic on heating. The test procedure has never been satisfactorily standardized because of the failure to find a source of inert material of sufficient uniformity so that different lots would give the same results with the same coal. This difficulty has been solved by chemists of the Coal Division of the United States Bureau of Mines, who have found silicon carbide in granular form to be satisfactory inert material sufficiently uniform so that different lots always give identical results.

ALL coking coals expand soon after they begin to melt or assume a semi-fused state. In the coking process, shrinkage of the coke coal and compacting of the uncoked charge go on simultantously with the expansion, so that with coals and mixtures of coals ordinarily used the pressure against the oven walls due to expansion is at no time sufficient to injure them. However, coals which expand excessively will deform the oven walls and the finished charges will stick so that they cannot be pushed from the oven. Other kinds of coking coals may expand so as to exert their maximum pressure on the oven walls at some intermediate stage of the coking period. These are the most dangerous coals, according to the United States Bureau of Mines, because they shrink sufficiently after the expansion stage is passed to enable the charges to be pushed easily, and damage to the oven walls may not be noticed until after such coals have been used for some time.

THE first article of this series which appeared last month outlined a few fundamental elements of turbines. This was preliminary, quite general in fact; now, in this article the author gets down to brass tacks and discusses the various types of turbines available and to what purpose they can be applied

MODERN TURBINES

By
L. E. NEWMAN
Turbine Div. General Electric Co.
Lynn, Massachusetts

MODERN TURBINES are "tailored" to meet specific operating conditions differing so widely from each other that rarely are identical turbines built for different purchasers. This is particularly true in the field of industrial manufacturers, embracing turbine generators rated from 500 to 7500 kw., and including almost every conceivable variation in type and operating conditions. Initial steam pressures, for example, range from atmospheric pressure to over 1500 lb. per sq. in., and this diversity of operating steam pressure coupled with other variables results in a different design for almost every application.

The first article of this series outlined a few fundamental elements of turbines; later articles will be directed at filling the gap existing between what has been published on the "design" of turbines and the "operation" of turbines. The entire series will attempt to furnish sufficient information to aid in making correct turbine applications, but before this can be done it is necessary to describe what is available and what are the variables, in other words, to review the turbine field and the apparatus it includes.

Turbines are broadly classified as "condensing" or "non-condensing", terms which refer to the turbine exhaust pressure. If the exhaust pressure is atmospheric or higher, the turbine is classed as "noncondensing" regardless of what is done with the steam after it leaves the turbine. If the pressure at the exhaust flange is less than atmospheric, the turbine is classed as "condensing." These two terms are uniform with all engineers having to do with turbines.

Figure 1-A is a simplified drawing of a multi-stage straight condensing or straight non-condensing turbine, in which the steam follows a single path from the time it enters the turbine, passes through the controlling valves, goes through the power producing portion consisting of the nozzles and buckets, and leaves the turbine exhaust. In terms of number of units of all ratings there are more straight condensing and straight non-condensing turbines in operation than all of the other types of turbines combined.

Many times, however, greater economy of power generation can be obtained by using a turbine from which part of the steam is taken out before it reaches the exhaust. When the steam does some work in a turbine and then is extracted at a pressure less than the initial pressure, but higher than the final exhaust pressure, the turbine is classed as an "extraction," or "bleeder," or (in Europe) "pass-out" type turbine. Steam flowing through turbines of this type also follows a single path but part way through the turbine a portion of the steam flowing to the final exhaust is diverted from the single path and extracted from an opening in the single casing.

Extraction turbines may be of two general types, "automatic," or "non-automatic," the distinguishing feature being the means for controlling the extraction pressure.

When turbines are provided with openings from which steam may be taken at a pressure which is not held constant, they are usually said to be provided with "non-automatic," "uncontrolled," or "bleeder" openings, terms all meaning the same thing. Figure 1-B illustrates this type of turbine, and it will be noted that a simple opening placed in the turbine casing is all that is needed to make a straight condensing, or non-condensing, turbine suitable for non-automatic extraction of steam.

All of the steam entering the turbines passes through the controlling valves; part may be extracted from the

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opening after the steam has done some work; and the remainder goes through the turbine and out the exhaust. The steam pressure at such a hole in the casing is *not* constant, but goes up or down in very nearly direct proportion to the quantity of steam flowing through the *following* stage. A simple analogy will show why this is true.

If a hole were punched in the bottom of a pail and the pail held under a faucet, the level of water inside the bucket would rise when the water was coming in faster than it ran out. But it would not necessarily continue rising. Within limits, as the water level in the

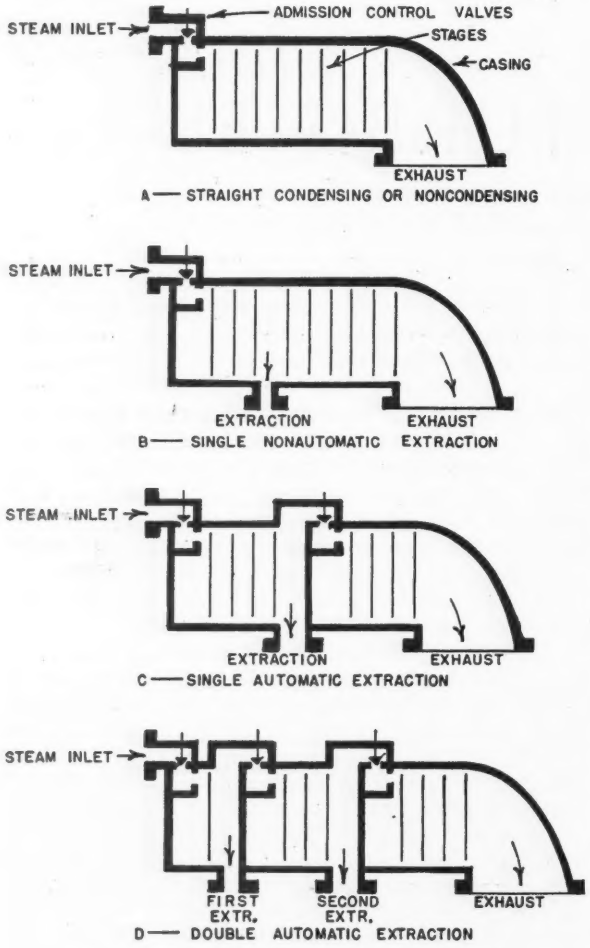


Fig. 1. The four general types of turbines available

pail rose, the pressure head of water would increase and force more water out of the hole in the bottom. This would continue until the depth of water in the pail had built up a pressure head sufficient to force out the same quantity of water at the bottom as came in at the top. At this point of equilibrium the water level would stay fixed. With more flow of water the level would rise, and with less flow of water the level, or pressure head, would fall.

The same thing happens in a turbine stage, except that the water is replaced by steam and steam pressure takes the place of water level. The orifice at the bottom of the pail corresponds to the fixed nozzle passages through which steam leaves one stage and goes to the

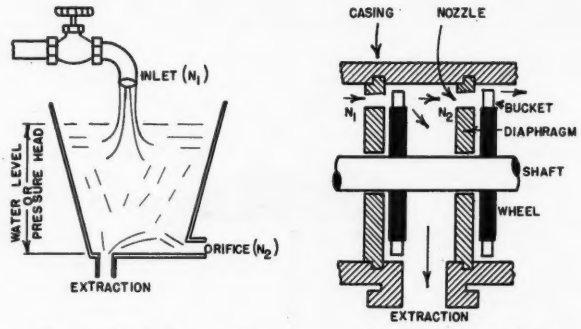


Fig. 2. Here the extraction pressure changes with the flow

next. Figure 2 illustrates this analogy plus the introduction of an extraction.

Assume that the orifice in our pail corresponding to the nozzles of the next stage of a turbine is a fixed size. Then the larger the extraction hole in the pail, or if this should supply something with water, the greater the flow of water taken from the pail, the less will be the pressure level. The pressure head of water in the pail will depend entirely upon the rate water comes into the pail, and the size of the discharge orifices.

This is true of a turbine where successive stages have fixed nozzles corresponding to the orifice in the pail. In a turbine operating with constant steam conditions each stage has a certain definite pressure for a given steam flow. At the high pressure end of the turbine stage pressures are high, gradually decreasing to the final exhaust pressure. As the steam flow through the turbine increases, the pressure existing in each of these stages rises, and as the steam flow decreases the pressures are reduced. So any steam taken from such openings in a turbine is not at a constant pressure but must be taken at whatever pressure exists in the stage for the particular flow of steam going through the stages following the opening at the time steam is extracted.

Variation in extraction pressure is not undesirable for certain applications, but when it is, one of two things may be done. Attach to a non-automatic extraction opening a reducing valve* (because of the frequency with which this is done, uncontrolled extractions are often called "reducing-valve" extraction openings) or apply on automatic extraction turbine.

An "automatic" extraction turbine (Figure 1-C) is one having an *internal automatic valve* maintaining the pressure of the extracted steam substantially constant. How this valve functions to maintain the pressure at

*A reducing valve is a pressure controlled valve holding substantially constant pressure at the outlet of the valve.

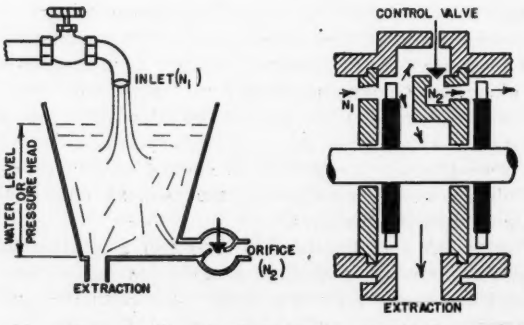


Fig. 3. In this case the extraction pressure is constant

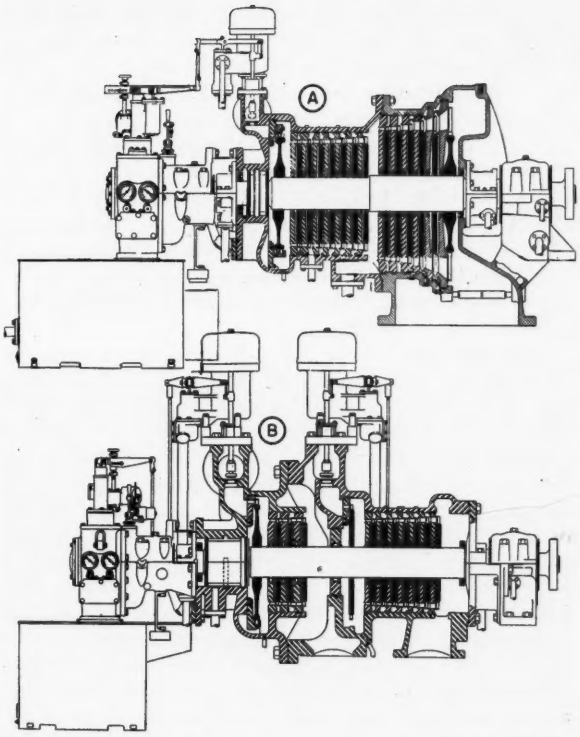


Fig. 4. Cross sections of (A) straight condensing turbine with provision for non-automatic extraction and (B) non-condensing single automatic extraction turbine

a set level is illustrated by the same type of analogy used to show why the pressure varied at an uncontrolled extraction opening.

Fixing the extraction pressure at a predetermined level is the same thing as maintaining the water level in the pail at a fixed height regardless of how much water is dumped in or taken out. Figure 3 shows the pail of water with controlling valve to regulate the flow of water leaving the pail. By changing the setting of this valve the water level of the pail could be held constant even though the rate of flow entering, and leaving through the extraction, changed.

In Figure 3 a turbine extraction stage has been sketched with the valve controlling the flow through the nozzles. Within the limits between the wide open and shut position of this valve the pressure in the stage can be held constant. The extraction control valve is automatic in its operation being always under the control of a governor actuated by the stage pressure.

Many automatic extraction turbines have a single opening for extraction of steam, but in certain industries large quantities of process steam are used at two different constant pressures, making it economical to automatically extract from the turbine at two points. Such machines are classed as "double automatic extraction" turbines. (Fig. 1-D)

In recent years a new classification of turbine has come into being, known usually as the "superposed" but sometimes aptly called "topping" turbine. A superposed turbine is the familiar non-condensing turbine except that it admits steam at a pressure far above common boiler pressures of past years, and exhausts the steam to the *inlets* of existing turbines or to the present station boiler header. Steam for these turbines if furnished by modern high pressure boilers generating steam at pressures of 600 lb. to 2000 lb. per sq. in. in general more efficiently than old boilers now installed. As more power can be generated from the same quantity of steam when the pressure is raised, these superposed turbines often cut fuel costs for power generation by 30 per cent or more when applied to existing stations with operating pressures of from 150 to 400 lb. per sq. in. Moreover the gain in economy for the complete station is often enough to make it comparable with recent high pressure condensing turbines and thus add many years of usefulness to old turbines which might otherwise be obsolete.

At the other extreme from superposed turbines are the "low pressure" turbines, taking steam at about atmospheric pressure and exhausting it to a condenser. It is a fact not generally appreciated that there is more energy available for power in steam expanded from atmospheric pressure to a high vacuum than from steam expanded from 200 lb.per sq. in. pressure to atmospheric pressure. Low pressure condensing turbines capitalize on this fact and generate power from waste steam ordinarily thrown away from steam hammers, steam engines, non-condensing turbines, heating line returns or any one of a number of sources of low pressure steam.

The principle of the low pressure condensing turbine is sometimes combined with the automatic extraction type turbine by admitting steam at the extraction opening instead of taking it out. The pressure in the low pressure admission stage is held constant by a controlling valve in the same way as described for extraction turbines except that low pressure steam is admitted to supplement the high pressure steam, both joining and flowing to the exhaust. When a turbine is suitable for admission of low pressure steam in addition to high pressure steam, it is termed a "mixed-pressure" turbine.

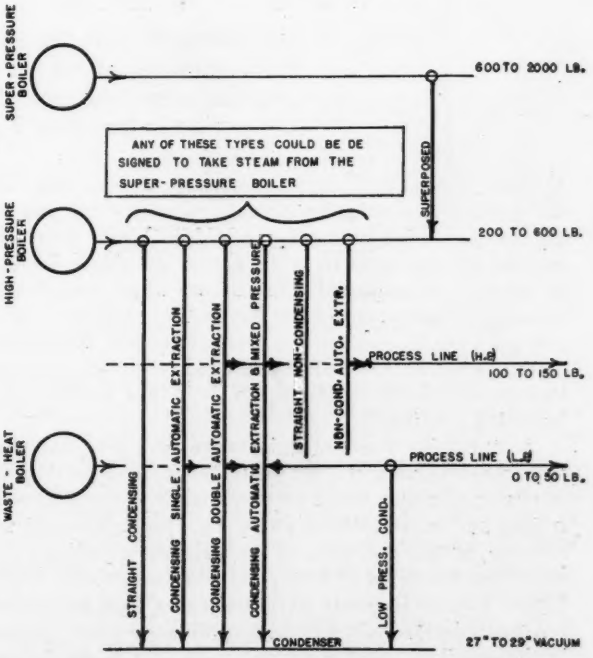


Fig. 5. Diagram showing the way various types of turbines are related to each other from the standpoint of the pressure levels and the division of steam flow.

The types of turbines classified by division of steam flowing into or leaving a turbine must not necessarily be limited to the types described. Turbines are often built so that steam may be extracted or admitted through the same opening (extraction, or mixed pressure) and most large straight condensing turbines have several of the simple type non-automatic extraction openings from which steam is taken to heat feed water before it enters the boiler.

Figure 4 is a schematic diagram showing the way the various types of turbines are related to each other from the standpoint of the pressure levels and the division of steam flow. Note, for example, that steam enters the condensing single automatic extraction turbine from the high pressure boiler, part is extracted to the low pressure process line, and the remainder is exhausted to the condenser. By definition, a single automatic extraction turbine is one from which steam may be automatically taken out at some fixed pressure less than the initial pressure, but not as low as the exhaust pressure. So it is apparent that the condensing single automatic extraction turbine need not necessarily feed the low pressure process line; it could feed the high pressure process line, instead, or any line requiring steam at a pressure less than the inlet but higher than the exhaust pressure. The inlet steam could be taken from some higher or lower pressure source of steam than the boiler shown on the diagram, but in general the diagram shows common pressure levels in addition to the types.

It is evident from these diagrams that turbines are built to suit a wide range of conditions. Consider that industrial type turbines are commonly built:

For fourteen (14) standard ratings between 500 and 750 kw., (smallest turbine is less than 1 hp. and largest is rated 208,000 kw.).

For operating speeds of from 1000 r.p.m. or less to over 10,000 r.p.m.

For initial pressures as low as atmospheric pressure to over 2000 lb. per sq. in.

For initial temperatures of only 200 deg. F. to over 950 deg. F.

For extraction pressures of less than atmospheric to over 400 lb. per sq. in.

For exhaust pressures of almost a perfect vacuum to over 400 lb. ga.

No other prime-mover has a like number of variables. The turbine, most flexible of all prime movers, is the only one capable of being built in the thousands of different designs necessary to meet the wide diversity of desirable applications. A different design is required for each rating and for each of the eight basic types shown in Fig. 4. For the 14 standard ratings between 500 and 750 kw., it would be necessary to have 8 times 14, or 112, different designs available to cover the industrial field if there were no other variables. But the type and the rating are the simplest variables of the designer! Diversity of steam pressures and temperatures increase the basic 112 different designs to many thousands.

Obviously in the usual sense of the word, there is no such thing as a "standard" turbine. But standardized parts may be assembled in thousands of combinations to meet the varied conditions, and each turbine made from these standard parts will be tailor made to fit the particular application.

Burning Natural Gas

University of South Dakota converts two 200-hp. boilers from stoker to natural gas firing. Boiler output increased and fuel costs reduced. Savings estimated to pay for conversion in less than 2 yr. under average conditions

EVER INCREASING, the network of pipe lines is making available the advantages of natural gas to rapidly increasing areas of the Middle West. In some sections low coal costs limit the use of this gas to domestic service or industrial applications where cost is of secondary importance. In other sections, however, natural gas is highly competitive in the industrial and power plant market. In Northeastern Iowa, Southeastern South Dakota and Southern Minnesota, it is in a particularly favorable position.

Just outside the economic range of North Dakota, Montana, Illinois and Iowa coals, this area depends primarily upon water borne eastern coal from the docks at Duluth and transportation charges are high. The area is, however, within the range of the main gas pipe line running from the fields of Texas and Oklahoma to the Twin Cities. Besides its many advantages as a fuel, gas therefore has a decided cost advantage and many power plants in the area have been converted from coal to gas firing.

One of the recent conversions was the power plant of the University of South Dakota at Vermillion, S. Dak. This is interesting not only because of the engineering involved but because of the method of payment and high rate of return on the investment. Records over a period of years showed an average annual coal consumption of 3781 t. costing, at $6.09 per t., a total of $23,016. On the basis that one ton of the coal as used at 60 per cent boiler efficiency is equivalent to 20 M.c.f. of natural gas at 70 per cent efficiency, the annual gas consumption was estimated at 75,620 M.c.f., costing, at the regular schedule, $15,600, or an estimated annual fuel saving of some $7400.

Figuring backward, it was determined that the two fuels would break even at a gas cost of somewhat over $0.30 per M.c.f. This was taken as a basis of payment and under the contract with the Vermillion Natural Gas Co., the University pays for the gas used at the rate of $0.30 per M.c.f., the difference between the amount paid and the regular gas schedule being used to pay off the conversion cost of $12,665. At the end of about 2 yr. the conversion will be paid for and the regular schedule will apply. This is a step rate ranging down to $0.20 for all

over 300 M.c.f. The estimated gas consumption ranges from 1800 M.c.f. in June to 13,800 M.c.f. in January, the average rate being approximately $0.222 and $0.203 per M.c.f. respectively.

This plant furnishes all the light, power, heat and water for the University. The electric load is carried by four generating units with a total capacity of about 535 kv-a., water is pumped by air lift from a deepwell and steam is supplied by four boilers, two 150-hp. and two 200-hp. units. The small boilers are 27 and the larger ones 22 yr. old and their limited capacity was a decided factor in the conversion. As reconstructed for gas firing,

Fig. 1. Front view of the two converted boilers

the two 200-hp. Heine boilers are guaranteed for a peak rating of 250 per cent and an efficiency of 76 per cent over the range of from 50 to 250 per cent rating.

Acceptance tests made by Professor M. W. Davidson, of the Department of Applied Science at the University, showed 77.5 per cent at 115 per cent average rating. During the test the average pressure was 139 lb. per sq. in., the feedwater temperature 102 deg. F. and the flue gas temperature and CO_2 at the boiler outlet was 410 and 424 deg. F. and 10.7 and 10.4 per cent respectively for boilers Nos. 4 and 3.

Furnace Walls

A cross section of the converted furnace is shown by Fig. 2. The first baffle was moved from above the first to the second row of tubes, the bridgewall was removed and the back of the furnace excavated to the ash pit level. The new floor was then built up of 5 in. of tile, ½ in. of millboard, 2½ in. insulating brick and 5 in. of firebrick. As shown by the drawing the tile gives an air cooled floor with the air passages terminating in a duct which leads up to the burner windbox in such a way that flow through the floor is induced by the main air flow to the burner. The 18 in. side wall is built up of 9 in. of firebrick backed by 9 in. of common brick but the front wall is 18 in. of solid firebrick.

The front wall of each boiler incorporates two No. 6 AL Webster Radiant low pressure gas burners.

A 6-in. gas header from the meter and regulator room runs over the top of the boilers and down to 8-in. subheaders on each boiler as shown by the photograph. A 3-in. line runs from the subheaders to each burner. A ½-in. raw gas pilot line for each burner is connected ahead of the plug valve in the 6-in. supply header. Combustion is controlled automatically by a Weco Series I, Precision control guaranteed to maintain the steam pressure within plus or minus 1.5 per cent of the desired value and the CO_2 at 10.2 per cent with a variation of not more than 0.2 per cent.

The conversion carried out by Stearns-Roger Mfg. Co. under the supervision of the Department of Applied Science, covered, in addition to removing the stokers, rebuilding the furnace and installing the burner, a complete oil standby installaion. This consists of a 11 ft. dia. by 30 ft. long 21,000-gal. underground storage tank, Hammel steam atomizing burners and the necessary oil pumps, heaters and piping.

Oil Standby

Pumps and heater are installed in a separate fireproof compartment next to the gas meter and regulator room. Each room has solid brick walls, a concrete slab roof, fireproof door and vapor proof electric wiring. The Emco gas regulator, set to maintain a 2 lb. gas pressure, and the Foxboro double range recorder, recording the static pressure upstream from the gas measuring orifice, and the differential pressure across the orifice, were installed by the gas company.

Oil equipment, however, belongs to the University and was included in the conversion contract. It consists of two Northern rotary pumps with a capacity of 250 gal. per hr. (each driven by a Wager ½ hp., 220-v. motor), one Ross oil heater and the necessary filters. Inasmuch as oil fuel is supplied primarily for standby service, the control is entirely manual. Except in emergencies the burners are not in place and the opening provided for them in the front wall above the gas burners as shown by Fig. 2 are normally closed off by 4-in. pipe caps. A Fisher valve is installed to keep the oil pressure at about 60 lb. at the burners.

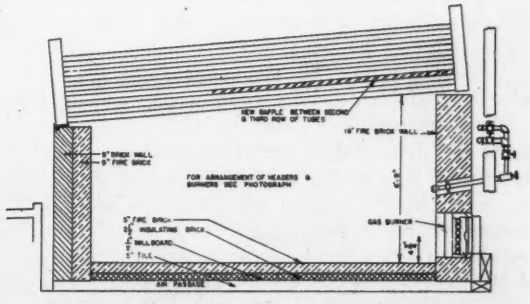


Fig. 2. Cross section showing the reconstructed boiler setting

In addition to the necessary oil, steam and gas pressure gages necessary for operation, a Ranarex CO_2 meter is installed and each boiler is equipped with a Bailey steam flow meter. The well water used for makeup, although relatively soft for that territory, has a hardness of about 44 grains per gallon and is treated by a Permutit Zeolite softener installed several years ago. W. L. Dustman, Superintendent of Buildings & Grounds, and also Chief Engineer of the plant, maintains close control of feedwater conditions.

Capacitors

Two 480 kv-a., 4000 v. Outdoor Ineerteen Type Capacitors.

DURING THE PAST FIFTEEN YEARS capacitors have been developed to a degree where they are used in a very large number of applications. The continued decrease in size and weight in the present small size is the result of years of research on materials, processing, and details of construction. The art of thin paper manufacture has progressed to a point where extremely fine control of thickness and electrical and physical properties is possible. Today both paper and foil 0.0003 in. thick, highly uniform and pure, are available.

Non-inflammable impregnating fluids have been developed which approach crystaline materials like mica, both as to dialectric constants and electrical loss.

Processing has been controlled to a point where losses less than one-third of 1 per cent are commercially obtainable.

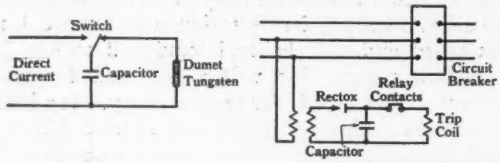
The development of a process of soldering porcelain to metal has solved the problem of hermetically sealing the units at the terminal bushings, thus preventing entrance of moisture, even in outdoor exposed applications. The development of that art has thus greatly increased the dependable performance of capacitors and materially reduced the selling price.

These reductions in size, weight, and price and increase in dependable performance have resulted in many new uses which at first were either impractical or uneconomical. The capacitor embodying these latest advances in construction is a reliable and useful device. In efficiency it stands at the head of the list of all electrical devices. It compares most favorably in cost, size and weight with the modern, highly developed transformer on a kv-a. basis. A 1200-kv-a. three phase, 2300-v. capacitor has about 38 per cent the weight, 64 per cent of the volume, requires 70 per cent of the floor space, and has about one-fifth the losses of a transformer of similar rating.

The outstanding use of large power capacitors has been in the correction of power factor. There are many other uses, however, some of which will be reviewed for the benefit of those not familiar with this device.

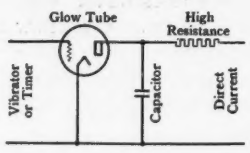
Most electrical equipment, such as motors, welders, utilize a magnetic circuit in their scheme of operation. This causes a flow of current in the circuit which is in excess of the actual power current or useful current. Also, this so-called wattless current is lagging with respect to the voltage, resulting in a lagging power factor. The cost of serving power to a consumer is increased by the presence of this extra current since the cost of generators, line transformers and other distribution equipment is largely proportional to current handled, rather than power delivered.

Since a capacitor draws a leading current, it may be connected across the line and used to compensate these inductive loads and remove this reactive current from the supply mains. That portion of the circuit between the capacitor and the load is not affected, but in the circuit from the capacitor back to the source the current is reduced. If the load power factor is 70 per cent, the reactive current in the line is equal to the power current and the line losses are double what they would be if the power factor was 100 per cent. Furthermore, the effect of this reactive current on the

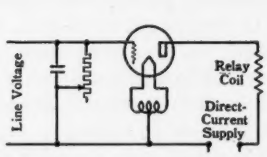


Scheme for percussion welding

A capacitor used to supply energy for circuit breaker tripping



Simplified stroboscope circuit



Time-delay opening of relay on failure of line voltage

—Their Growing Use in Power and Industry

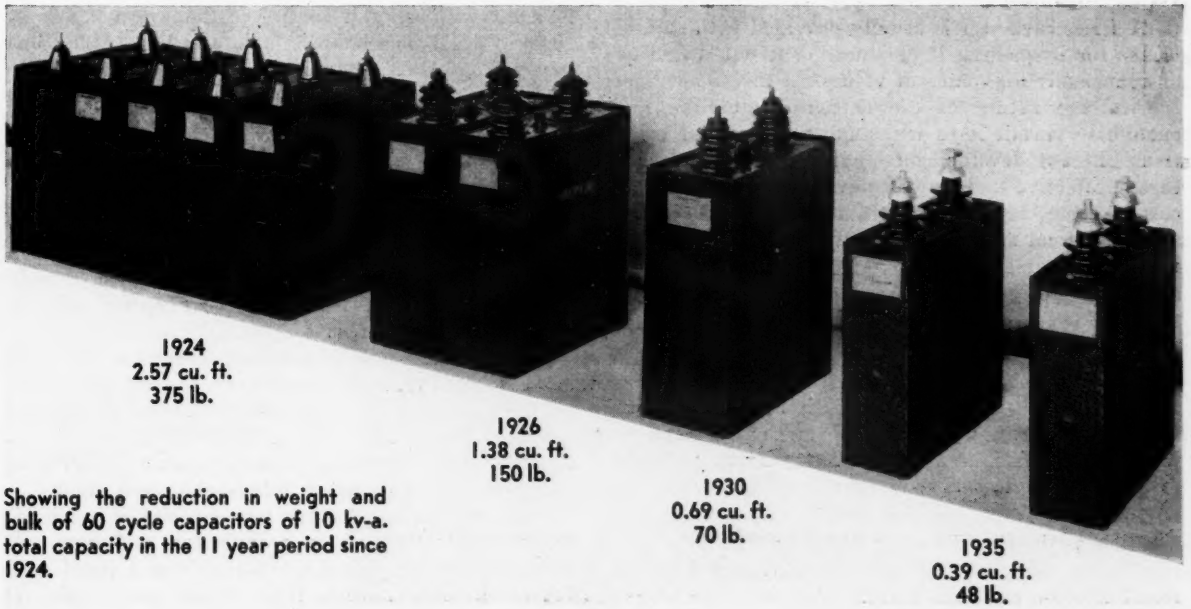
By R. E. MARBURY

Switchgear Engineering Department
Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.

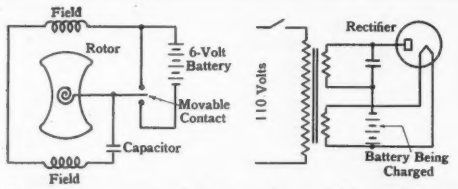
voltage of a typical distribution circuit is very important, since the reactive current causes over twice the voltage drop as an equal amount of in-phase or power current.

Where the loads are large enough to justify it, such as in most industrial plants, capacitors may be installed to correct the power factor at the service entrance. Capacitors applied in this manner are called shunt capacitors. The major portion of the saving resulting from such capacitors takes the form of reduced losses in the power distribution system, and released system capacity. Where there is a market for the additional power that can be handled by the distribution system, and generators, the power companies reimburse the power users because of this improvement in power factor. Various tariff systems are in use which take into account the power factor of plant loads. In many cases the reduction in rates is quite substantial in proportion to the cost of the capacitors. A few such cases are listed as follows:

Type of Consumer	Cost of Capacitor	Monthly Average Saving	Yearly Saving
Municipality	$6480.00	$600.00	$7200.00
Scale Manufacturer ..	3700.00	241.00	2890.00
Vehicle Manufacturer	5000.00	757.00	9084.00
Welding Plant.....	5500.00	268.00	3216.00
Spring Plant.....	400.00	30.00	360.00
Automobile Dealer...	238.00	18.00	215.00
Apartment Hotel.....	490.00	47.50	570.00
Office Building.....	3500.00	208.00	2500.00

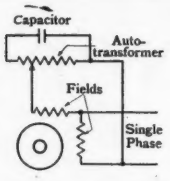


Showing the reduction in weight and bulk of 60 cycle capacitors of 10 kv-a. total capacity in the 11 year period since 1924.

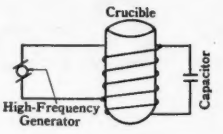


Electrical escapement for clocks, using an oscillating rotor actuated by capacitor discharge and timed by natural period of rotor and spring

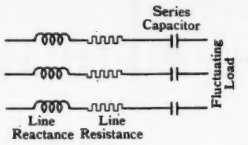
A capacitor used to protect a rectifier tube from surges produced by closing the line switch



Scheme of the capacitor-type motor



High frequency, coreless type induction furnace



Series capacitors used to improve voltage

Where the loads are very small and scattered, such as in residential districts, it is not practical to correct the power factor at the load. The small kv-a. rating of such capacitors, together with the low voltage of these circuits, usually 230 volts, makes the cost per kv-a. many times the cost of larger and higher voltage ratings. The logical step in these cases is to install the corrective equipment on the distribution circuits. Pole type capacitor units may be installed in banks of 30 to 180 kv-a. or individual 10 or 15 kv-a. capacitor units may be placed out on single phase circuits at the primary side of distribution transformers. In this manner the reactive kv-a. is removed from a major portion of the distribution system. This makes it possible to handle an increased kw. load with the same voltage drop or to reduce the voltage drop with the same load. It is also possible to bring about a definite control of voltage by automatically switching such capacitors on and off, according to line voltage.

Abrupt changes in the load on a circuit causes changes in voltage at points along the line which cannot be connected by slow acting voltage regulators designed for steady state conditions. If a capacitor is connected in series with the line, improvement in voltage regulation takes place because a part or all of the reactive drop in the line itself is neutralized by the capacitor. Series capacitors are, therefore, very useful in reducing such voltage dips that cause lamp flicker.

A series capacitor is usually provided with suitable means for by-passing it or shunting it out in periods of abnormally high current values. If this is not done, the voltage rating of the capacitor must be high enough to permit it to withstand short circuit conditions. Recent developments that have taken place in these protective and control devices have brought the cost of series capacitors down to a point where they are a practical means of eliminating these sudden dips responsible for lamp flicker.

Shunt capacitors, therefore, improve voltage regulation by reducing line current for a given load. Series capacitors correct the power factor of the circuit by creating voltage to offset reactive voltage drop.

The stored energy in a capacitor is used in the scheme of operation of many devices, such as in the welding of metals, high voltage X-rays, surge generators, the Stroboglow, operation of tripping devices, etc.

In the welding process two metals are brought together as the stored energy discharges at their junction point. The welding takes place very quickly before oxidation can take place.

In certain types of X-ray work the charge in large high voltage capacitor is released through an X-ray tube giving an intense X-ray emission of short durations, thus making it possible to photograph moving organs in the body in the same manner as camera snap shots are made under ordinary light.

In making certain electrical test analogous to lightning strokes or surges, it is necessary to pass an enormous current through the device on test. A device for accomplishing this is known as a high current surge generator, and consists of a large bank of capacitors and rectifier means for charging them. The low internal resistance of capacitors and the short leads in the apparatus makes it possible to obtain surge currents of 150,000 amp. or more.

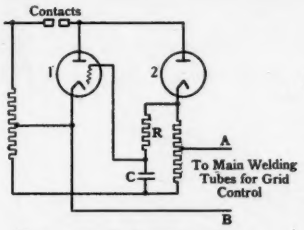
The stored energy in a comparatively small capacitor may be used to actuate the trip coil of a circuit breaker. A small inexpensive rectifier keeps the capacitor charged and ready at all times. Such a tripping device represents an extremely small burden on the potential transformers, it is reliable and has no moving parts.

Quick response of lamp filaments is needed where automatic oscillographs are used to record power circuit disturbances. Disturbances lasting only a few cycles would be missed ordinarily because of the delay in lighting the oscillograph lamp. A 20 mf. capacitor charged to 110 v., when discharged through a 4-v. filament will bring it to full brilliancy in 0.001 sec. (0.06 cycles). The lamp is maintained at normal brilliancy from 110-v. source through suitable resistance.

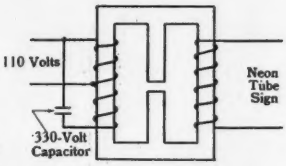
The Stroboglow, by which it is possible to view the blades of an airplane propeller or similar moving objects, depends on the discharge of the stored energy in a capacitor through a neon lamp. At controlled periods a 500 amp. capacitor discharge lasting 10^{-6} sec. is allowed to pass through the neon tube. When these intervals of illumination repeat themselves in synchronysm with the moving object, this object appears stationary. Strains set up due to motion may be studied in this manner.

When a capacitor is energized through a resistance, or discharged through a resistance, the voltage change on the capacitor has a definite time constant depending on the value RC. This principle is made use of in timing devices utilizing capacitors, as in controlling spot welding, time delay relays and even clocks.

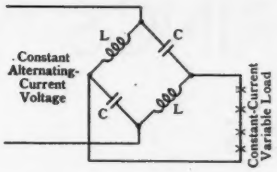
One form of no voltage trip consists of a holding coil which is shunted by a capacitor, and both supplied with continuous d.c. voltage from a small rectifier of the copper oxide type. When power fails the



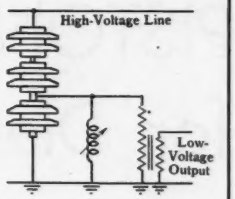
Time-controlled spot welding circuit, using electron tubes



A luminous tube transformer having a high power factor



The principle of the monocyclic square, constant current regulator



A scheme for securing a small quantity of power from a high voltage transmission line

stored energy in the capacitor continues to flow through the holding coil. When the voltage decreases to the drop out point of the coil the breaker trips. Time delays of 5 to 10 sec. are easily obtained in this manner.

In one type of electric clock which utilizes an extremely small amount of energy, the capacitor is charged and discharged from a dry cell by a contact actuated by a simple motor rotor which also acts as an escapement and driving device for the clock. The discharge of the capacitor energizes two field coils which supply the mechanical impulse needed to keep the rotor oscillating. The natural period of the rotor with its spiral spring controls the time.

Some devices require a great amount of magnetizing current in proportion to the power current and, therefore, have very low power factor. It is desirable in these cases to correct the power factor by means of capacitors at or near the individual device. Examples of this are neon sign transformers and high frequency induction furnaces.

It is common practice in the case of neon sign transformers to bring out a tap from the primary winding for connection to a capacitor rated at 330 v. or higher. This takes advantage of the lower cost of higher voltage capacitors.

High frequency induction furnaces utilize the heating effect produced by a large magnetic field when a crucible containing metal is placed in the field. The power factor is necessarily very low, sometimes only 10 per cent. Unless the power factor of such a furnace is corrected the generator cost would be prohibitive. This is a case where power factor is necessary for the practical operation of the device.

Tuned circuits consisting of capacitors and inductances are used in numerous ways, such as in filters, wave traps, voltage regulating devices, and various applications where selectivity is necessary. They are used usually to discriminate as to frequency, taking advantage of the product LC.

Parallel turned circuits are used to block out or prevent the flow of certain harmonics or high frequencies, or to screen off portions of a circuit, eliminate radio interference, etc.

Both series and parallel resonance circuits are used to produce oscillations of desired periods.

The low impedance of capacitors due to their inherent characteristic makes them suitable for suppressing contact arcs, and changing the slope of traveling waves, and for passing a.c. and blocking out d.c. when desired.

Capacitors are often connected close to rotating machines between line and ground. As a lightning surge reaches the machine it will be loped off and will not build up a high voltage across the end turns of the winding, but will be more distributed, stressing the insulation more uniformly. Capacitors are also used in this manner to protect trolley car motors.

Capacitors are also used to produce a phase displacement in motors, giving an approach to two phase motor performance on single phase supply.

Like many new devices, capacitors are often misapplied. They may be misapplied as to type, rating, or as to installation conditions. Certain types are suited to certain applications only, such as wax impregnated units. Years of study are necessary to determine operating limits and establish ratings, working stresses for the materials and other limit conditions.

Capacitors properly constructed properly rated and correctly applied require practically no maintenance and have unlimited life.

Solder to porcelain capacitor terminal construction

PISTON RINGS for Diesels

PART II—In Part I the general factors influencing piston rings selection were discussed and compression rings covered in detail. This part covers the detail of oil rings and proper oil drainage and recommends clearances for rings of all types

By E. STEAD
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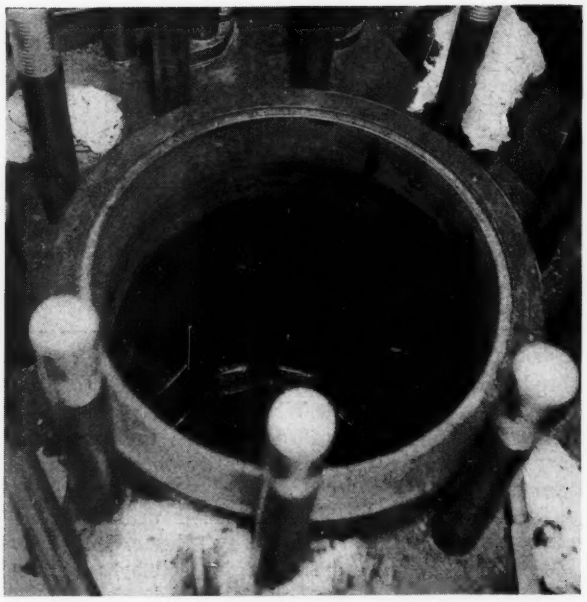
Koppers Company, Baltimore, Md.



A horrible example of scoring by poorly fitted rings

OIL CONTROL RINGS may be divided roughly into two classes: first, those which are not slotted for oil drainage and, second, those which are slotted. The simplest of the unslotted rings is the plain beveled ring shown in Fig. 5. It is still in quite general use but, with with this ring, there is a tendency for oil which has been scraped from the cylinder wall on the down-stroke of the piston to pass across the lower face of the ring into the annular space in the groove behind the ring and, on the reversal of the stroke, to seep out past the upper face of the ring. The tendency of the oil to work past the ring in this way is largely overcome by grooving the lower face of the ring as, for instance, in the special beveled and grooved ring shown in Figs. 6 and 7.

Excess oil scraped from the cylinder wall by a ring of this type is generally drained back through the wall of the piston by holes drilled into a chamfer or oil collecting groove around the lower edge of the oil ring groove as shown in Fig. 6. When the oil ring is so near the bottom of the skirt of the piston that the section of the skirt below the ring groove can be cut away without an objectionable decrease in the bearing area of the piston, this section of the piston may be reduced in diameter as shown in Fig. 7. Oil which is removed by the ring is then drained directly down the cylinder wall around the outside of the piston. This is an effective method of oil drainage and some gas and Diesel engines are now being built with this feature incorporated in their original design.

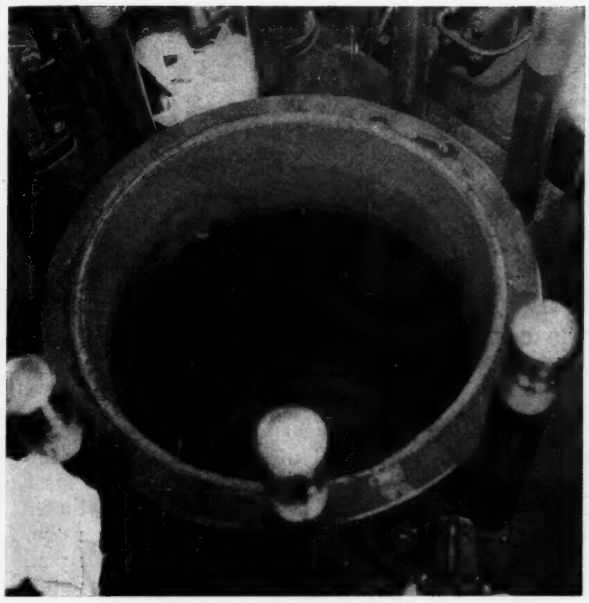
An oil ring must not only remove oil from the cylinder wall but it must also remove the oil quickly. Therefore, a large area of drainage is essential. When holes are used, they should be as large and numerous as can be used without weakening the piston to such an extent that there will be any danger of breakage occurring while in operation. With a slotted oil ring, as for instance with the scraper drain ring shown in Fig. 8, the drainage holes should be drilled through the back of the oil ring groove, perpendicular to the axis of the piston. It is advisable to have the holes almost as large in diameter as the width of the oil ring groove except perhaps in the case of extremely wide grooves and it is also advisable to have them located midway between the top and bottom of the groove.

If the holes are not sufficiently large and are drilled downward at an angle to the axis of the piston from the lower corner at the back of the groove, the oil which is being scraped from the cylinder on the down-stroke of the piston will accumulate in the upper part of the space behind the ring and some of it will be more likely to find its way past the ring than will be the case when numerous large holes are drilled cenrally in the back of the groove. In grooving a piston for use with a slotted oil ring, the oil ring groove should be made deeper than the compression ring grooves. If the annular space back of the oil ring is too small, there will again be danger of the oil being forced from this space out past the ring on to the cylinder before it has a chance to be drained back into the interior of the piston.

Piston Ring Clearances

After an engine has become worn to such an extent that its oil consumption is far above normal, it frequently becomes necessary to add more oil control rings and to provide more oil drainage than that which was provided when the engine was new. Also, various combinations of rings mentioned above may be used. For instance, special beveled and grooved rings may be used on the skirt while scraper drain rings are used above the piston pin. All of the compression rings may be tapered, and at the same time they may be provided with step seal joints to avoid blowby in tapered cylinders. Another combination of compression rings consists of plain angle joint rings in the upper grooves and multiple-piece rings in the lower compression ring grooves.

When an engine is overhauled, the grooves should be carefully inspected and, if worn unevenly, should be trued up so that the new rings may have a flat



Cylinder wall well polished by well fitted and selected piston rings installed with the proper clearance and regard for operating conditions

bearing on their side faces. The ideal condition is to have the rings seal as well against the sides of the piston grooves as valves seal against their seats. Otherwise, pressure will work around behind the rings and leak out across their lower faces. In truing up grooves, it is good practice to make the first two grooves 0 002 in. wider than the lower compression ring grooves In this way, all of the compression rings may be made with the same face width or, in other words, they will be interchangeable so that any of them may be used in any of the compression ring grooves while still the two top rings will be provided with more side clearance than the lower rings.

Side Clearance

Some engines require larger side clearance than others. For instance, there are some gas engines in which the rings invariably become stuck if the top rings are not provided with at least 0.016 in. side clearance. This would be excessive on many other engines and, therefore, an operator must use his best judgment in applying any standard rules to his particular conditions. Consequently, the minimum side clearance listed in the table[2] will not be applicable everywhere but they may serve as a guide for general use.

[2]From the Engineer's Handbook, Copyright, 1935, by the American Hammered Piston Ring Co.

As mentioned at the beginning of this article, the end clearance, or gap of the ring when placed in the smallest part of the cylinder, is also of vital importance. An example of this was noted on a two-cycle Diesel engine with a cylinder bore of approximately 5 in. The rings were originally fitted with an average end clearance of 0.015 in. They wore rapidly, however, and were found to be badly scored. The average end clearance was then increased to 0.030 in. Considerable scoring was still experienced and the end clearance had to be increased to 0.045 in. before satisfactory operation was obtained. This may be somewhat of an extreme case but it is always safer to fit rings with slightly more clearance than is absolutely necessary because, in case of cylinder distortion, ring flutter, or expansion of the rings under the influence of heat, the damage which is caused by the butting of the ends of the rings is far more than that which will be caused by the leakage of gas through a gap a few thousandths wider than necessary, especially if some form of seal ring is used in the lower compression ring grooves. As a general rule, it is recommended that piston rings in Diesel engines and gas engines be fitted with an end clearance of at least 0.006 in. per inch of cylinder diameter.

MINIMUM RECOMMENDED SIDE CLEARANCE FOR RINGS

Cylinder Diameter	Minimum Side Clearance in Inches			
	4-Stroke Cycle Engines		2-Stroke Cycle Engines	
	Top Ring	Other Rings	Top Ring	Other Rings
Below 6 in.	0.003"	0.002"	0.005"	0.004"
6 to 12 in.	0.004"	0.003"	0.006"	0.005"
Over 12 in.	0.006"	0.004"	0.008"	0.006"

Even with the best of rings, an engine cannot be expected to work well for any length of time if the rings are poorly fitted. In this connection, another crude comparison might be made between men and engines. For instance, a man may buy the finest shoes in the world, but if they do not fit him properly, he will soon slow down. Similiarly, an engine cannot do its best work if its rings are not fitted properly and the analogy might be carried further by saying that tight fitting rings—like tight fitting shoes—are the worst in the long run.

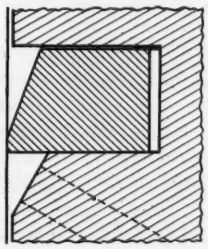


Fig. 5. The plain unslotted beveled ring oil ring may have poor oil drainage

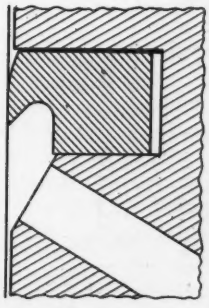


Fig. 6. Drainage may be improved by grooving the underside of the oil ring

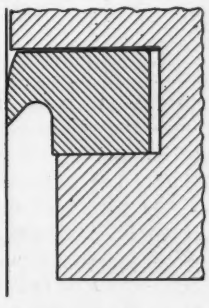


Fig. 7. In some cases the skirt of the piston may be reduced in diameter to facilitate

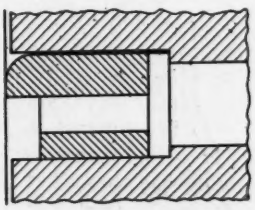


Fig. 8. In other cases the ring may be slotted and oil drained through the back of the ring

3500 hp. Opposed Piston Diesel built in England

New unit will bring the capacity of the Bermuda Station to 10,000 hp.

ALTHOUGH 3500 hp. Diesels no longer come in the record breaking class, they are still sufficiently uncommon to be worthy of comment. The new Fullagar engine recently constructed for the Bermuda Electric Light, Power & Traction Co. is unusually interesting because it represents the latest practice in construction of this opposed piston engine of unique design. The new engine brings the capacity of the station up to a full 10,000 kw. All engines are of the same general type, the last unit added in 1930 being rated at 2500 hp. The English Electric Co. Ltd. has been building this type of engine for air injection for 15 yr. The design, however, was such that it was well adapted to mechanical injection and as the result of a research program successfully completed some time ago the entire line of solid injection engines ranging from 4 to 8 cylinders, 980 to 3500 hp., has been developed. The Bermuda engine is the largest and most recent of the line, being a 19 by 22 in. eight cylinder unit with a normal rating of 3500 hp. at 214 r.p.m. As installed in Bermuda it will operate at 200 r.p.m. and have a full load rating of 3275 hp. The smaller size engines have a bore and stroke of 14 by 16 in.

Fullagar engines are of the two cycle opposed piston design with a tie rod arrangement that requires only one crank per cylinder giving in effect a double acting engine without cylinder covers. Cylinders must of necessity be arranged in pairs, the assembly being shown diagrammatically by Fig. 2. Each cylinder has two pistons connected with diagonal tie rods as shown so that the piston of one cylinder works in parallel with the bottom piston of the other cylinder. Side

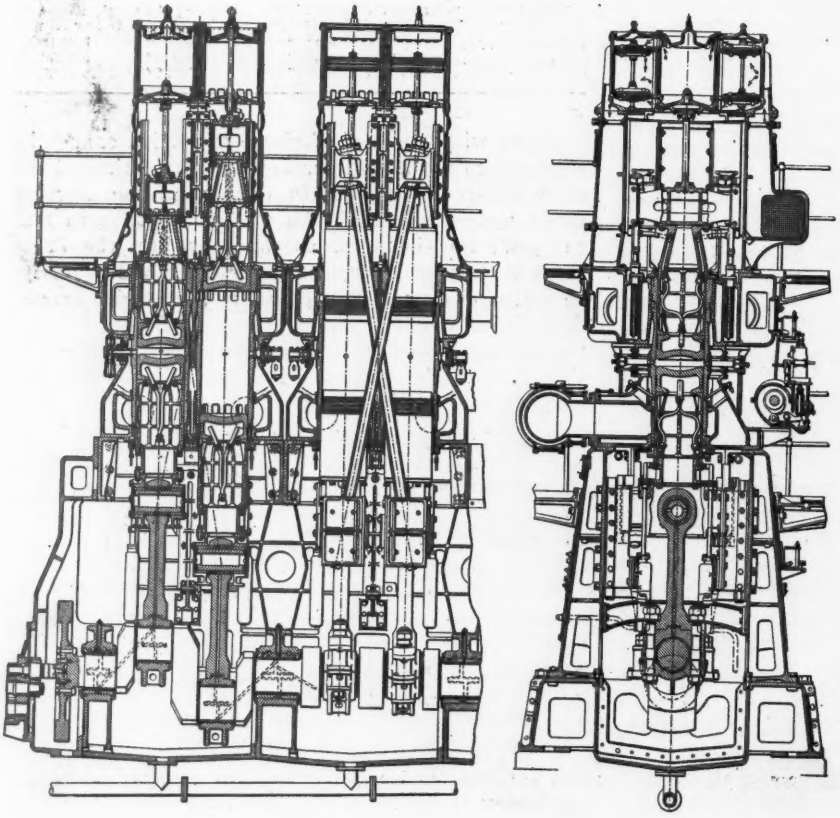


Fig. 1. Partial longitudinal section and cross section of the engine. The bore and stroke are 19 and 22 in. respectively. The unique tie rod arrangement used requires but one crank per cylinder for the double acting cylinder. Scavenger pumps are mounted directly on the top piston and fuel is injected through two diagrammatically opposed nozzles. The engines are built in sizes up to 3500 hp.

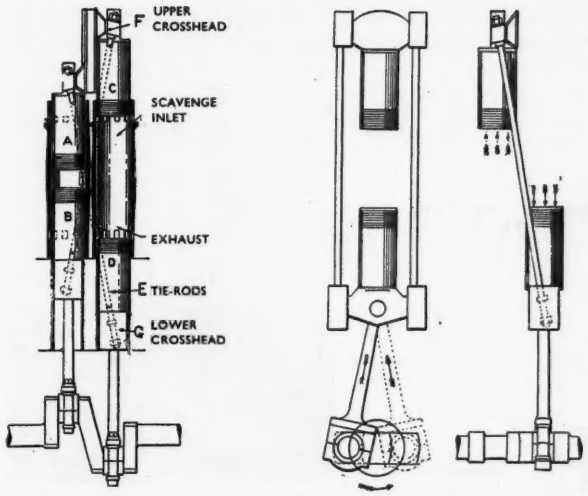


Fig. 2. Diagrammatic arrangement of Fullagar opposed piston arrangement which requires but one crank per cylinder

thrust is taken by cross heads at top and bottom.

Fuel is injected between the two pistons from two nozzles in opposite sides of the cylinder and scavenge ports open slightly after the exhaust ports located on the opposite side of the cylinder. In the smaller engines scavenge air is supplied from a rectangular piston directly connected to the upper pistons, in the larger sizes the arrangement is slightly different as shown by Fig. 3 although the scavenge pump pistons are still direct driven from the upper piston.

Pistons are oil cooled, the telescopic arrangement being indicated by Fig. 1. The camshaft along the front of the engine is driven through a short vertical shaft from the flywheel end of the engine. Bosch fuel pumps are also mounted on the front of the engine just above the camshaft. Oil pressure from a gear pump driven from the crankshaft provided in two pressure stages, a low pressure for lubrication and a high pressure for piston cooling. The cooling water pump is a separate unit.

Net weight of the large engine runs about 115 lb. per hp. and floor space is lower than needed by the conventional engine. Comparison of a 980 hp., 300 r.p.m. Fullagar engine with a 1000 hp., 375 r.p.m. conventional four cycle engine of compact design is said to show a floor space saving of about a third.

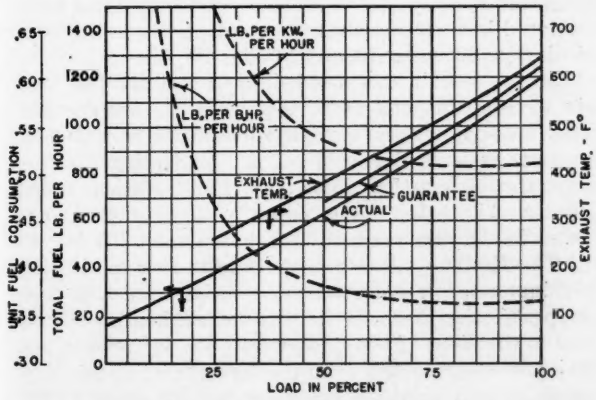
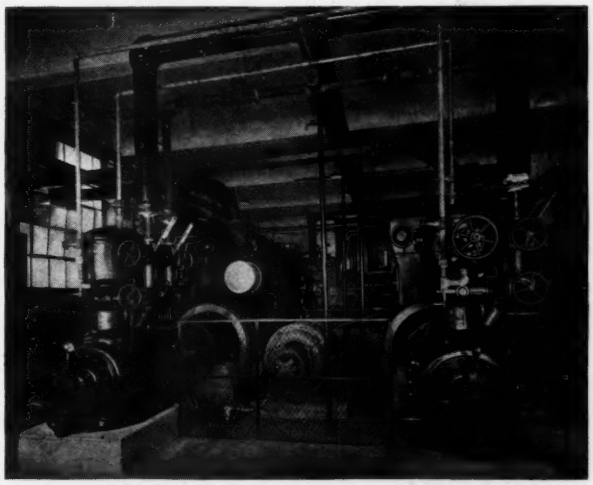


Fig. 3. Test performance of the engine at a speed of 200 r.p.m. at which the full load rating is 3275 b.hp. At 214 r.p.m. the rating is 3500 h.p.

At a crankshaft speed of 214 r.p.m. the piston speed is 785 ft. per min. The calculated b.m.e.p. is 65 and the i.m.e.p. 81 lb. per sq. in. and the scavenge air pressure ranges around 1.8 lb. per sq. in. From the performance curves Fig. 3 it will be seen that the minimum fuel consumption of 0.365 lb. per b.hp.hr. comes at about 85 per cent load although it is below 0.3675 for all loads above 75 per cent. Actual exhaust temperatures range from somewhat below 270 deg. F. at quarter load to approximately 640 deg. F. at full load. Actual fuel consumption on a pound per hour basis considerably betters the guaranteed values.

Diesel Refrigeration

AS PART of a modernization program to increase capacity and lower costs, the Southern New England Ice Co. at Bridgeport, Conn., recently installed four Frick 10 by 10 enclosed ammonia compressors. These compressors are driven by direct connected Superior Diesel engines. One 420 hp. engine drives two compressors and a Crocker-Wheeler generator

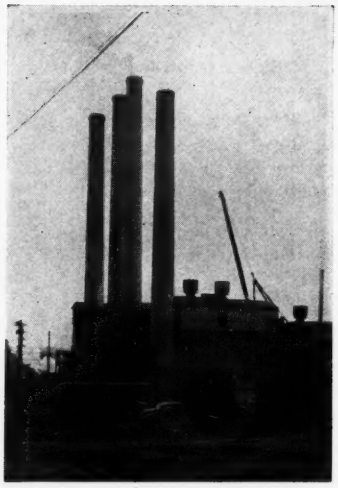


Two Superior Diesel engines driving four 10 by 10 Frick compressors at Southern New England Ice Co. plant. The generator in center may be V-belted to either engine

V-belted from the fly wheel as shown by the illustration. The 300 hp. engine drives the remaining two compressors and in emergencies may be belted to the generator, the design and arrangement of the equipment being such as to facilitate this change.

On the second floor of the plant is a 100 t. ice tank arranged for a 13 can grid lift. The smaller tank on the first floor can be brought into service when the demand warrants its operation.

Adjoining the engine room is a small brewery which is idle at the present time but the company expects to bring it into use as soon as the modernization and general expansion program in the ice plant has been completed.



Another "TOP"— Here's One For CEDAR RAPIDS

"TOPS" are coming so thick and fast these days that it is difficult to keep track of them all. In both large and small stations, in public utility and in industrial plants, the practice of superposing a high pressure non-condensing turbine on the existing low pressure equipment is gaining headway to such an extent that from some quarters warnings are being sounded to the effect that the idea must not be regarded as a panacea for all present day power problems. And this warning is quite in order for while the practice of superposition is an excellent one its use demands careful study of operating statistics and characteristics of the station as its success or failure depends on the high load factor and high degree of demand availability on the part of the new equipment.

The idea involved in superposition is to restore an existing station to a high degree of economy and at the same time bring about an increase in capacity. Steam plants do not depreciate as rapidly as they become obsolete due to the advance in the art of steam generation and use. There are, of course, certain elements of a power station that do become obsolete and there are certain elements of a power plant that resist obsolescence to a high degree. The real estate, the buildings, the water supply, stacks, screen house, the coal handling, the side tracks and much of the electrical gear are items which do not readily become obsolete. The steam generating equipment, fuel burning equipment and the prime movers, on the other hand, do become obsolete due to the advance in the art which has brought about higher pressures and temperatures with a consequent reduction in B.t.u. per kilowatt hour of net output.

The installation of a superposed turbine with the necessary high pressure boiler equipment is one way of restoring an existing station to a high degree of economy, but as pointed out above before such a course is adopted, a careful study of operating statistics and characteristics is desirable. In a plant where the high load factor necessary for the superposed unit is not available it will be more desirable, perhaps, to actually tear out the existing boiler equipment and prime mover and install a straight through high pressure machine.

At the Cedar Rapids station of the Iowa Electric Light and Power Co. the superposed unit was adopted because it fitted the peculiar conditions of operation at this plant to an unusual degree. This plant is peculiar in that it furnishes large quantities of steam to a central heating system. All other possible systems were analyzed but none of them were adaptable to the particular conditions existing at Cedar Rapids.

So a top unit was decided upon and for the past six months this has been in process of construction. This installation, now completed, consists of a 700-lb. pressure boiler and a 5000-kw. non-condensing turbine-generator exhausting into the 110-lb. station steam header. The boiler has a capacity of 300,000 lb. per hr. at 700 lb. pressure and with the steam at 765 deg. F.

The 210-lb. header supplies steam to four condensing turbines and to a non-condensing turbine which in turn supply exhaust steam to the city central heating system and to the plant of the Quaker Oats Co. for process use. The fuel cost resulting from the superposing of this high pressure unit on the entire plant will be about 11,200 B.t.u. per gross kw-hr.

An interesting thing about the new boiler, which

of course is true of most modern units, is the fact that it is installed in the space formerly occupied by two low pressure boilers which together had a total steaming capacity of 50,000 lb. per hr. These old boilers were removed to provide space for the new. Thus the new unit provides six times as much steaming for the same floor space.

The new boiler and furnace were built by the Springfield Boiler Co. As shown by the sectional view in Fig. 1 it is of the cross drum straight tube type with an interdeck Elesco superheater and equipped with a water cooled underfeed stoker which was largely developed by the personnel of Cedar Rapids station. The slope of the tubes in the lower bank is at 15 deg. from the horizontal while the slope of the tubes in the upper bank is 25 deg. This was done to facilitate tube removal and provide better circulation within the upper rows of boiler tubes. A slag screen 17 in. deep is provided with provisions made to increase its depth to 27 in.

The furnace is completely water cooled on all sides by walls of 3-in. bare tubes placed on 3-9/10-in. centers. Through the center of the furnace a double water wall extends from below the stoker to a point within the superheater zone, thus dividing the furnace into two parts. This double water wall is composed of 3-in. bare tubes on 3-9/10-in. centers placed back to back. The object of this center wall is to introduce greater cooling effect into the furnace as it is necessary to cool the gases below the sticky point of the ash before they enter the slag screen. This was deemed necessary as it is expected that the boiler will be operated at high ratings for long periods and slagging of the tubes cannot be tolerated. The lower header supplying water to the inner wall is below the stoker while the upper header is above the superheater zone. At full load in excess of 50 per cent of the steam generated, is made by the furnace walls.

The design of the furnace and stoker, in fact the steam generating unit as a whole, was based largely upon the characteristics of the coal used at this station. This coal is from Atkinson, Illinois, with an ash fusing temperature of 1900 deg. F. It was this low temperature ash fusing point that was the determining factor in the design of the equipment.

The water cooled stoker selected for this boiler was made by the American Engineering Co. Considerable experimenting on water cooling underfeed stokers was done during the past few years at the Cedar Rapids station, and at the present time eight of the underfeed stokers used are water cooled. Prior to water cooling the tuyeres it was impossible to keep a boiler on the line for more than an hour at normal load when burning low fusion ash coal. With water cooling, however, this coal has been burned successfully at the rate of 55 lb. per sq. ft. of stoker area (air admission part only) with no ill effect on the stoker, the limiting factors being sufficient air and steam relieving capacity of these old units. The general effect of water cooling the tuyeres is to freeze the molten ash quite some distance up from the fuel bed which allows unrestricted flow of air and proper functioning of the stoker. It was because of this extensive experience with water cooling of stokers that this type was selected for the new boiler.

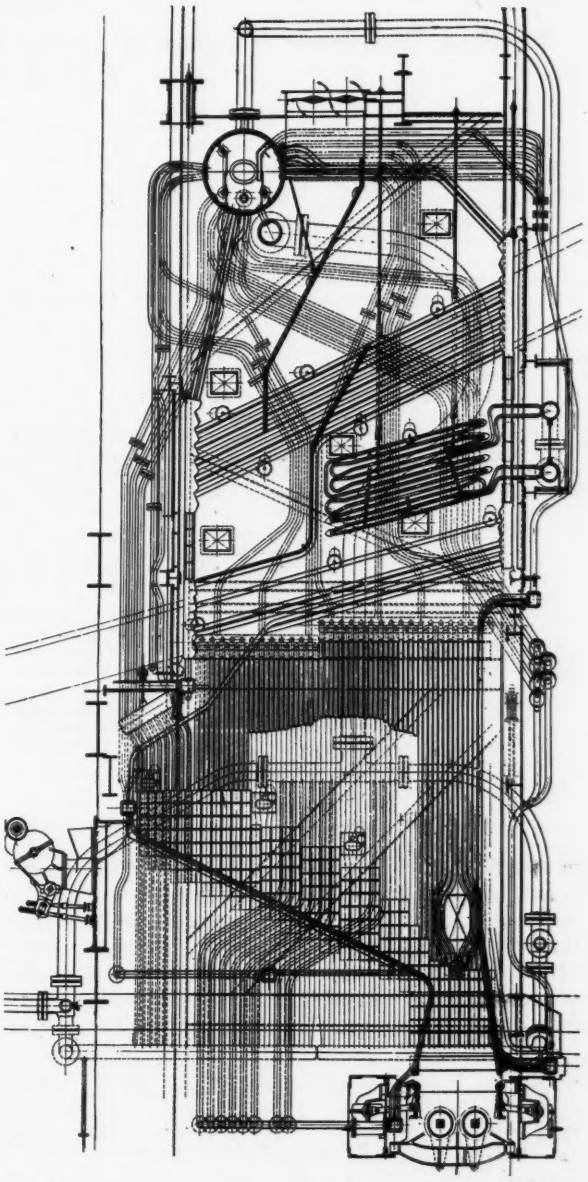


Fig. 1. New steam generating unit rated at 300,000 lb. per hr. at 700 lb. pressure 765 deg. F.

The water used in cooling the stoker tubes is taken from the drum into a header near the toe of the stoker below the clinker rolls. It then passes through the tubes on the tuyere stacks and up through the first row of slag screen tubes into the rear boiler header. The stoker is equipped with steel clinker grinder rolls, the teeth of which are so arranged that only a few are in grinding position at a time. This reduces the power required for grinding and relieves supporting steel of high stresses as clinkers from the coal burned are very hard.

The arrangement of the boiler is shown in the cross section. The superheater is of the conventional interdeck type supported by rods hung from the steel above the boiler to hangers above the tubes. Each tube is attached to its neighbor immediately above by means of a movable toggle joint which is welded to the tube.

Principal Equipment Installed at Cedar Rapids Power House in Connection with the 700-lb. Boiler and Turbine

BOILER AND FURNACE—Made by Springfield Boiler Co. Steam generated at 700 lb., 765 deg. F. total temperature, 300,000 lb. per hr. straight tube, 3 pass boiler, 13,389 sq. ft. of surface. Elesco interdeck superheater. Tubes of lower boiler deck slope 15 deg. from horizontal. Tubes of upper boiler deck slope 25 deg. from horizontal. Upper deck has 52 tubes across and 10 tubes high with provision made for two additional rows. Lower deck has one complete row of 48 tubes across with provision made for an additional row. Below this desk is slag screen space. Slag screen is 17 in. deep with provision made to increase its depth to 27 in. without changing furnace volume. Tubes in slag screen 10¾ in. apart. Headers are of cast electric steel. Drum is 54 in. inside diameter and 30 ft. 6 in. long. Drum completely welded, welds X-Rayed. All pressure parts designed for 750 lb. operating pressure.

Furnace is completely water cooled on all sides. The walls are water cooled by 3-in. bare tubes placed on 3-9/16 in. centers. A double center wall goes through furnace with 3-in. bare tubes placed on 3-9/16 in. centers. The upper header of center wall is within the superheater zone and the lower header is below the stoker. Effective furnace volume is about 7500 cu. ft.

Walls in coal area protected by iron blocks cast weld onto tubes.

Total water wall surface in furnace is 7137 sq. ft.

SUPERHEATER—Elesco connection superheater, 4533 sq. ft. Elements welded to headers.

STOKER—The stoker is made by American Engineering Co. and is water cooled by two 3-in. tubes on each tuyere stack. Stoker has 545 sq. ft. of projected grate area. It is not equipped with metered air control but provision is made for such. Stoker water cooling surface 600 sq. ft.

ECONOMIZER—Foster Wheeler extended surface economizer 4608 sq. ft., 8 high, 12 wide, 16 ft. long—provision made for four additional rows of elements. Equipped with cast iron hopper.

SOOT BLOWERS—Diamond Power Specialty Corp., 12 units.

BLOW-OFF VALVES—Yarway. Yarnall-Waring Co.

WATER COLUMNS—Reliance "Hi-Lo". Reliance Gauge Column Co.

SAFETY VALVES—Crosby.

FEEDWATER REGULATORS (Water level)—Bailey Meter Co.

AIR HEATER—Ljungstrom air heater 29½ in. elements, 20,500 sq. ft. surface. Provision made for 44 in. elements.

FORCED DRAFT FAN—B. F. Sturtevant Turbo vane double inlet fan with vane control, 90,000 c.f.m., 13.8 SP, 1160 r.p.m. Driven directly by a constant speed squirrel cage G. E. motor, 300 hp., 1160 r.p.m.

INDUCED DRAFT FAN—American Blower Co. ID fan equipped with a Sirocco dust collector, speed controlled by a 42 in. hydraulic coupling, 11.5 in. SP, 160,000 c.f.m. at 260 deg. F. gas driven by a constant speed squirrel cage G. E. Motor, 500 hp., 585 r.p.m.

BOILER FEED PUMPS—2, Allis-Chalmers double suction 665 g.p.m., 1480 ft. head, 3560 r.p.m. feedwater pump, one motor driven, the other turbine driven. Motor 350 hp., 3560 r.p.m. Turbine 400 hp., 4000 r.p.m., Allis-Chalmers.

FEEDWATER HEATER — Closed feedwater heater, Foster Wheeler Corporation. Deaerating Heater—Cochrane Corp.

REDUCING VALVE AND DESUPERHEATING STATION—Smoot. Republic Flow Meters Co.

COMBUSTION CONTROL—Askania Regulator Co.

PIPING—Crane Company.

VALVES—Edward Valve Co. and Crane Co.

FURNACE WALLS—Bigelow Liptak Corporation.

FLOW METERS—Bailey Meter Co.

PRESSURE FILTERS—Permutit Co.

PRESSURE GAGES—Consolidated Ashcroft Hancock Co.

THERMOMETERS—Leeds & Northrup Co. and Foxboro Co.

DRAFT GAGE—Hays Corporation.

TURBINE AND GENERATOR—5000 kw., 70 per cent p.f., 3 ph., 14,000 volts. Exhaust steam at 230 lb. abs. No bleed points, generator air cooled General Electric Co.

SWITCHGEAR—General Electric Co.

TRANSFORMERS—General Electric Co.

This arrangement provides good supports which are cooled by steam within the superheater.

The economizer is located on top of the boiler. This is a Foster Wheeler unit of the extended surface type with 4608 sq. ft. of surface. The economizer elements are made to form U-bends requiring joints only at one end. Provision was made in the design of the economizer casing so that four additional rows of elements can be added at a future date increasing the effective economizer surface by 50 per cent. A special cast iron hopper supports the economizer so that the air heater and economizer can be washed and the water drained off without going through the boilers.

The air heater is of the Ljungstrom type and is

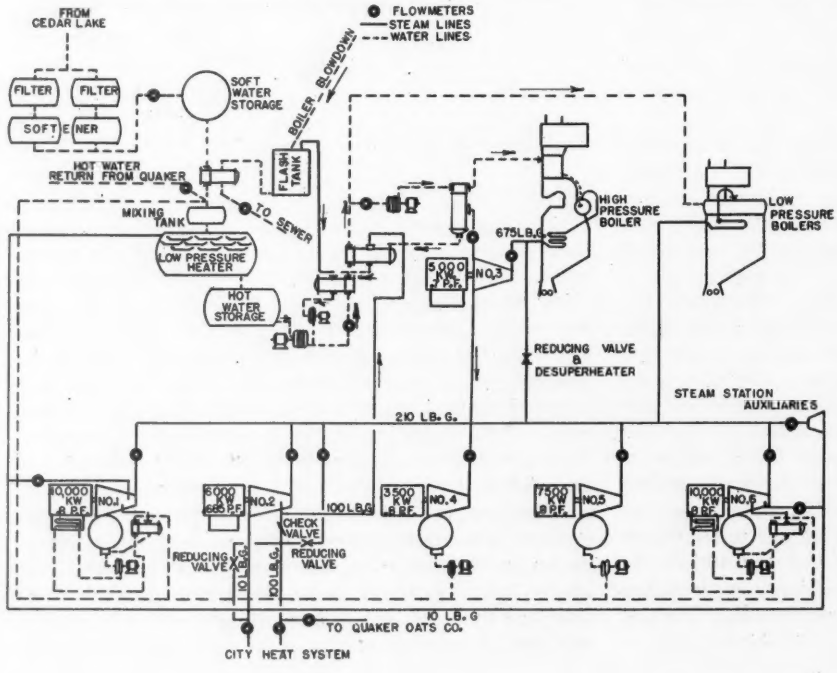


Fig. 2. Flow diagram for Cedar Rapids Station of Iowa Electric Light and Power Co.

placed directly above the economizer. It is provided with a special rapper which shakes the elements after each revolution. The design of this rapper was worked out by the Cedar Rapids operating force.

Forced draft is supplied by a turbo-vane double inlet design driven by a constant speed squirrel cage motor. The induced draft fan is a double inlet unit of the sirocco type fitted with a centrifugal dust collector which removes most of the dust in the flue gas before it passes to the fan. The induced draft fan is driven by a constant speed motor through a 42 in. hydraulic coupling. By raising or lowering the oil level in the coupling the fan speed may be increased or decreased.

The arrangement of the new boiler and turbine with respect to the existing station equipment is shown in the flow diagram in Fig. 2. The high pressure boiler header it will be seen leads directly to No. 3 turbine which is the new unit. A by-pass is provided around the turbine so that in the event the turbine trips off, the reducing valve and desuperheating station automatically provides 210 lb. steam to the old station header. This desuperheater is of the venturi type using boiler feedwater for desuperheating. The reducing valve is of a double seated tight closing design so constructed that the valve stem and seat always present a venturi nozzle effect, thus reducing wire drawing and wear.

As the city heating system and the adjacent Quaker Oats Co. plant are supplied with steam from which there is little or no condensate return, the percentage of boiler feedwater make-up is high, sometimes averaging in excess of 50 per cent. Because of this, it was considered desirable to treat the raw feedwater in such a way that it would cause no scale, no corrosion or embrittlement and if any solid matter were carried over by the steam it would pass through the turbine in the form of a dry dust and not adhere to the blading. The treating system selected takes water from the present zeolite softeners after which it receives sulphuric and phosphoric acid. After the water leaves the deaerating heater sodium sulphite is added to remove the last traces of oxygen. The method of water treatment was worked out by Professor Fredrick G. Straub.

Two boiler feed pumps are provided for the new unit. These are of the double inlet type, one driven by a steam turbine, the other by a constant speed motor. The flow of water to the boiler is controlled by a Bailey 3-element feedwater regulator.

Combustion control is effected by means of equipment supplied by Askania Regulator Co. The forced draft fan is controlled by furnace draft while the induced draft fan is actuated by steam header pressure and drop across the boiler proper. For the present the stoker will be hand controlled.

The 5000-kw. non-condensing turbine generator requires little comment. The turbine is of the impulse type direct connected to a 5000-kw. 70 per cent power factor, 3 phase, 1400 v. generator. The use of a 3 phase generator is an innovation in this station since all the old units are 2 phase, 2300 v. machines.

The new installation was designed by the Engineering Department of the Iowa Electric Light and Power Co. under the general direction of John M. Drabelle, Mechanical and Electrical Engineer. Construction work was done by the Beck Engineering Co.

Advancing an Industry

FORWARD-LOOKING leaders in every industry are always seeking means to advance the growth of that industry as a whole, usually by extending knowledge among those whom the industry can serve, of the help it can give them. In the power field, the Edison Electrical Institute, by awards for papers on various aspects of electrical service and for notable performance by companies and by individuals, seeks to accomplish this purpose. Other engineering societies have similar awards for outstanding achievement. In the welding field, a private organization, The James F. Lincoln Foundation, Cleveland, Ohio, has set up a program for a like purpose, which is somewhat of an altruistic innovation and may well lead the way to like movements by other industrial leaders. The Award Program set up is safeguarded from exploitation by the conditions laid down.

For each kind of application, a contest is set up, with a prize for the best paper submitted; the sectional winners will then be studied for those to be considered in the main award; and the final choice will be made from these selected papers. Total of 400 prizes is provided running from $100 up to $13,700. The purpose of the Award is stated by the management as the arousing of interest among engineers and executives as to the advantages that arc-welding offers over other methods in manufacturing and construction work. The intent is to stimulate study and investigation by executives or men whom they may designate, or by individuals on their own initiative, of present products and methods and how welding can be utilized to reduce costs and improve products. The belief of the Foundation is that a large number of those who make such a study will prove to themselves that arc-welding should be utilized.

In any such movement, there must be sufficient stimulus to awaken activity and, for those making the studies this takes the form of possibility of winning a substantial prize, recognition by their companies and personal advancement; for the organizations, the reward would be lowering of cost and betterment of product from the use of improved methods with enhancement of the prestige of the products and the organizations.

Since all papers will be treated as confidential and none published whose author requests that it be not done, exploitation is avoided. And the condition that a machine or structure need not be actually built, makes papers by men who are examining possibilties but who are not experienced in welding, as available for award as those from experts in welding. Spreading of interest and awakening executives to possibilities of using arc-welding is the end sought, rather than to reward actual achievement in welding.

This would seem a real effort to spread industrial, economic research, which may well be extended in all fields, in order to advance industry. And the Foundation is to be commended for its pioneer work to advance the interests of welding as an economic benefit to society.

Indicating the High Speed Diesel

Part I. Indicators have been the useful and constant companion of engineers since the time of Watt. The high speed Diesel, however, introduced factors that made new type indicators necessary. From a background of years of experience with internal combustion engines, the author discusses different types of indicators, their limitations and use. Part I classifies indicators and discusses those which give a complete diagram in a single cycle, Part II takes up the point-by-point and sampling indicators which give an average of many cycles, while Part III tells from actual cards what the indicator card discloses and how it should be analyed.

By E. T. Vincent,

Chief Engineer, Diesel Div.,
Continental Motors Corp.,
Detroit, Mich.

PURCHASERS of prime movers are interested primarily in the power output for a given quantity of fuel consumed no matter what the particular application may be. This probably accounts for the development of satisfactory and accurate instruments for the measurement of horse power and suitable means for measuring the fuel consumed over a given time, the combined and proper use of the two on the test stand, guaranteeing the purchaser certain performance characteristics.

There are many applications where, once the equipment has been installed, it is impossible to check the performance with any degree of accuracy while connected to its everyday load. Efficient maintenance is more a case of experience and hit and miss procedure. To meet such cases, efforts have been made from the earliest times to secure a record of the work done by the engine by means of a record of pressure and volume changes of the working medium in the engine cylinder.

Elementary principles show that the work done by any expanding gas or vapor is the $\int pdv$ where p is the pressure at any instant and dv an increment or small change of volume. The value of this integral for a complete cycle gives the amount of work done by the medium. The product pdv represents the area under or inclosed by curves which record the changes of pressure in an engine cylinder plotted on a volume base. By constructing an instrument called an indicator to record the changes of pressure and volume in the engine cylinder, we obtain what is known as an indicator diagram from which it is possible to determine the work done by the medium in the engine cylinders.

In the earliest days of the steam engine such diagrams were about the only means of measuring the power developed by an engine. The early forms of indicators consisted of a piston moving in a cylinder against a calibrated spring and subjected to the pressure in the engine cylinder so that any movement of the piston represented a definite change of pressure, to some scale, while the volume change was represented by the movement of the paper on which the diagram was drawn. This movement was usually secured by reduction gearing directly connected to the piston or some continuation of it. At first sight this appears a simple, direct, and accurate means of recording the required information but in practice the difficulties encountered are rather great, a few of these will be mentioned later. The indicator diagram so obtained was used to determine the I.H.P. or indicator horse power of the engine. This is the gross work done by the medium on the pistons and does not take account of that fraction of this work lost in overcoming the frictional resistances of the various parts. It, therefore, represents the maximum possible work obtainable from any engine.

The Indicator

Comparison of these diagrams with what was expected from the engine revealed differences for which explanations had to be found and eventually the indicator becomes a tool of the development engineer rather than a means of measuring horsepower. There are, however, many cases where the instrument is still the only means of determining the power output of the engine in service and in such cases it is used periodically to check adjustments and the condition of the engine.

In these notes it is proposed to consider the engine indicator chiefly from the standpoint of the development engineer where its greatest use occurs but to cover sufficient ground to permit the operator to be able to use the information in the diagnosis of defects, etc., and to secure adjustment enabling maximum efficiency of plant operation.

Fig. 1. Oscillations in indicator diagrams caused by inertia of the indicator piston and moving parts. This effect rapidly increases at higher speeds and rapid pressure rises. Note the effect of increasing the engine speed from 1500 to 1600 r.p.m.

E. T. VINCENT

THOSE ATTENDING various society meetings have been impressed by Mr. Vincent's wide knowledge of the internal combustion engine field. Although taking part freely in discussions, he speaks only when he has something worth while to say. His remarks are to the point, delivered modestly and sincerely, yet with the quiet assurance of one who does things.

His knowledge has been accumulated through a lifetime of intimate contact with all phases of engine practice. Born in Kent, England, in 1893, he served a six-year apprenticeship on submarine Diesel engines in the British Admiralty, after which his technical education was completed in the Imperial College of Science and Technology, London, where he was awarded the Whitworth and Royal Scholarships.

Appointed as senior laboratory assistant to the Admiralty Engineering Laboratories in 1917, he was promoted to Techniacl Secretary to the Superintendent. Leaving in 1922 to become Chief Experimental Engineer of Messrs. W. Beardmore Co. of Glasgow, he was responsible for the development of the Diesels used in the British dirigible R 101.

With this background he came to this country in 1928 as experimental engineer for the Emsco Aero Engine Co. of Los Angeles, Cal., and since 1930 has been chief engineer of the Diesel Engine Division of Continental Motors Corp. This year he was appointed Professor of Mechanical Engineering at the University of Michigan, at the same time maintaining his position with the Continental Motors Corp.

Familiar with all phases of engine development, both in this country and abroad, he knows from first hand experience the part the indicator has played in the development of engines and the limitations on their use when applied to high speed engines.

There are several types of indicators which may be roughly divided into classes depending upon the type of diagram obtained. A broad subdivision would be as follows:

A. Complete diagrams of one individual cycle.

1. Those employing a reciprocating piston fitted with a recording mechanism consisting of mechanical linkage or optical magnifying means.
2. Diaphragm instruments where a deflection of a diaphragm under the action of the cylinder pressure is used to record the pressure changes, this deflection being magnified by optical or electrical means.

B. Diagrams built up from a number of successive cycles.

1. Sampling type where the pressure at one particular point of the cycle is allowed to communicate with the recording mechanism which registers this pressure on the diagram, then by shifting the phasing of the point a complete diagram is obtained over a number of cycles.
2. The balanced pressure indicator where the cylinder pressure at one phase of the cycle is matched against a known external pressure.

It is not proposed to describe all instruments coming under the various headings but to select typical examples of each type in order that the limitation of the design can be easily understood.

Piston Type Instruments—A1

The piston type instrument fitted with a magnifying recording mechanism is a development from the original Watt indicator and, when handled correctly, proved quite satisfactory for the slow speed type of engine. As speeds began to increase it was apparent that the type possessed certain fundamental defects the chief of which was associated with the mass of the moving parts and the frequency of pressure applications. In the case of the steam engine the rate of change of pressure during admission is relatively slow compared with the explosion process in an internal combustion engine and the advent of the latter at once forced the development of a special instrument suitable for the changed conditions.

The rapid pressure rise during combustion is, naturally, accompanied by rapid motion of the recording piston and attached mechanism, and inertia effects result in violent oscillation similar to that shown in Fig. 1. This renders the diagram useless, and the rapid increase in vibration for a small speed increase should be noted. Weight reduction of all parts was carried out as far as possible to eliminate this defect.

Harmonic Vibrations

Oscillation of the recording mechanism also began to creep in due to another cause, one which can not be taken care of very easily, that is, forced vibrations due to some harmonic component of the pressure curve. The piston and pencil mechanism are in reality a weight system attached to a spring and have a definite period of free vibration. If a force of the correct frequency is applied, excessive vibration of the mechanism builds up quickly and this can be overcome only by change of frequency of the force or the frequency of the indicator mechanism. The indicator design must be such that its period of oscillation is far removed from that of any frequency component of the pressure curve, a condition almost impossible to meet in modern high speed engines. The mechanism should be as light as possible and the scale of the spring should be as high as possible. This latter requirement can be met only by reducing the size of the indicator diagram to the point where it begins to lose its usefulness.

Special types of the piston indicator soon appeared, the weights were reduced and periods of vibration increased as much as possible, coupled with reduced motion of the mechanism all of which enabled improved diagrams to be obtained at continually increasing

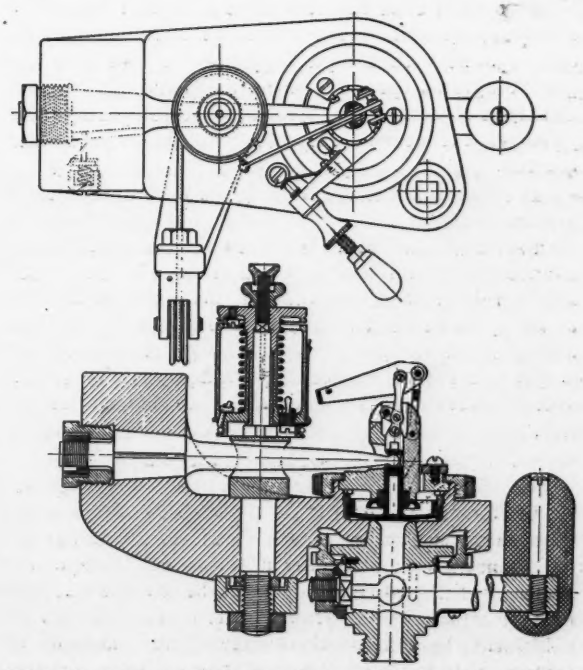


Fig. 2. Sectional and plain view of a modern piston type indicator designed for speeds up to 1500 r.p.m.

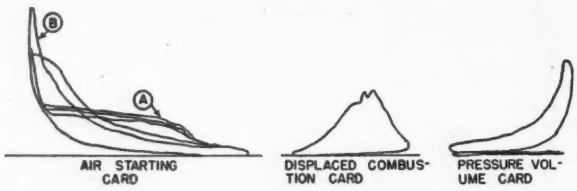


Fig. 3. Typical indicator cards taken with the type of instrument shown by Fig. 2. Left, air starting card A with B, the first explosion. Center, displaced combustion card. Right, typical pressure-volume card

speeds. Magnification of the piston motion was sometimes effected by optical means as in the Hopkinson indicator.

A modern form of a piston type instrument claimed to be capable of recording up to about 1500 r.p.m. is shown in Fig. 2. The cantilever spring has a high period of vibration when attached to the very light weight piston and mechanism.

In using such instruments even at moderate speeds great care still is necessary to obtain satisfactory results. Some of the precautions are as follows:

1. The indicator cylinder should be cleaned and oiled between each diagram.
2. To prevent the parts from heating up the instrument should be connected to the gases in the cylinder only at the instant the diagram is taken.
3. To keep it cool the piston should be removed from the cylinder when not in use.
4. The pressure of the tracing point on the recording drum must be as light as possible and upon a surface with as little friction as possible.

Samples of indicator diagrams taken with instruments of this type are shown in Fig. 3. The air starting card shows air admission along lines A while B is the first explosion.

Diaphragm types of indicators use the deflection of a metal disc, usually with a multiplying mechanism of the optical type with a source of light reflected by a mirror actuated by the movement of the diaphragm, can be built with a high frequency of vibration and good diagrams can be secured at fairly high speeds. This type is, however, subject to the disadvantage that photographic means are necessary to obtain permanent records.

The box to house the light beam, mirror and photographic plate, etc., is rather heavy, and, being mounted on a somewhat small fitting screwed into the indicator connection, it is difficult to avoid vibrations of the plate holder relative to the beam of light, due to deflections of the cylinder head under the action of the gas forces acting in the engine cylinder. This gives the indicator diagram a rather ragged appearance, and, at certain speeds where synchronism exists, the diagram is useless.

Diaphragm Type Instruments

In common with all types where the deflection of a diaphragm is used to record pressure, difficulties are experienced with obtaining accurate calibration. For accuracy the instrument should be calibrated after every two or three diagrams. It is preferable that the calibration be done on the engine while it is in operation in order to secure temperature conditions identical with those during actual use, a very difficult set-up. It is considered that the limitations of this type of instrument plus the skill required in manipulation place it in the laboratory type and its workshop use is limited.

Instruments so far discussed are of the type where one cycle is recorded completely, hence the mechanism must be capable of extreme high speed in order to follow the rapid fluctuations of pressure. This means robust mountings and large forces even when extremely light parts are used.

Modern Individual Cycle Indicators

Modification of the above types, when coupled to a cathode ray oscillograph eliminates most of the objections but photographic means are still required for permanent records. In addition care has to be exercised to insure perfect phasing and deflections which are proportional to the pressure. This combination of some form of pick-up coupled with a cathode ray oscillograph is, however, perhaps the most satisfactory of the modern single cycle recording mechanisms and with additional development of the pressure element should result in a satisfactory laboratory instrument.

Almost all of the modern single cycle indicators are built up of electrical circuits involving amplifying valves, etc., in conjunction with a cathode ray oscilloscope. It is not proposed to describe such an instrument in any great detail since it is rather complicated but it is desired to indicate its general characteristics.

The basis of the instrument is the cathode ray tube in which, as is well known, the beam of rays may be deflected by the application of a potential across the path of the rays. By arranging the tube with two sets of plates at right angles to each other, the beam can be deflected in two directions at right angles to each other. One of these is coupled to the pressure measuring device and the other to a means usually arranged so that the deflection is proportional to time. Thus a normal type of indicator diagram on a time base is obtained.

Cylinder Pickups

Apart from the various amplifying circuits, controls, etc., the cylinder pick-up is the other important unit in the system. Unfortunately the simplest and better of the pick-ups develops a voltage which is proportional to the velocity of the moving element giving a direct diagram which is a rate of change of pressure card instead of the usual pressure change. Inte-

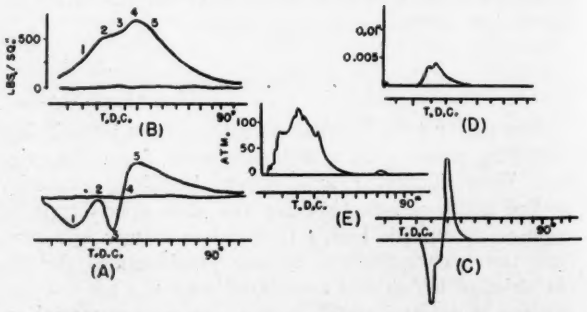


Fig. 4. Diagrams obtained from an indicator using the cathode ray oscilloscope. The direct diagram, A, gives the rate of pressure change in the cylinder and this must be integrated to give B, the normal pressure diagram. C and D are similar complementary diagrams of valve lift and, E, a normal diagram showing pressure variations in a fuel pipe

grating circuits are built into the mechanism so that the normal pressure-time diagram can be obtained directly. A very simple basic principle is involved and since, except in the pick-up, no moving parts are involved one in which inertia effects are practically eliminated.

The pick-up is usually built with a diaphragm which deflects under the action of the cylinder pressure, altering the magnetic flux or inductance in an iron circuit around which is wound a coil. Variation of the flux in the circuit results in the generation of a voltage in the coil, in fact the set-up is along the lines of the telephone receiver earpiece reversed, and, since the voltage generated can be amplified at will, extremely small deflections coupled with a high natural frequency of vibration can be secured. Deflections of 0.0005 in. and vibrations of 40,000 cycles per second can be used. This frequency is above that of the pressure waves associated with detonation.

In the case of pick-up units designed for use with the fuel injection system of high speed Diesel engines, natural periods of 60,000 cycles per second have been used thus permitting recording of very high speed pressure fluctuations in the fuel systems. Apart from the many and varied applications that can be made with the cathode ray oscillograph for recording changes of pressure associated with engine development, the same apparatus can easily be applied for the direct measurement of deflections associated with torsional vibration, etc.[1]

This type of instrument, in common with most human developments, is not without its defects and disadvantages. It is not the accurate instrument some would have us believe. It is still necessary to calibrate it accurately if the figures are to be strictly comparable but by using the instrument in an intelligent manner, a high degree of accuracy can be secured.

Figure 4 shows diagrams obtained from such an indicator, A, being the rate of change of cylinder pressure which when integrated gives diagram, B, of usual form. Diagram, C, shows the rate of change of valve lift and, D, the actual life, while, E, records the pressure variations in a fuel pipe. The chief point to observe in these diagrams is that the rate of change diagram brings out the actual start of any particular event far more clearly than the change diagram. This is a distinct advantage for many of the modern research problems such as fuel testing where ignition lag is required.

Considering diagrams A and B; Point 1 corresponds to the point of maximum rate of change of compression pressure; point 2 shows the beginning of combustion; point 3 gives the maximum rate of pressure rise during combustion; point 4 a position of no rate of change of pressure, or the maximum pressure point; point 5 is the maximum rate of pressure fall during expansion. Comparison of the corresponding points on the two diagrams shows how clearly the change points show up on the rate of change diagram.

[1]For the complete description of such an instrument, together with circuit diagrams and typical cards, the reader is referred to "The Engineer" December 13, 20 and 27, 1935.

Brick Plant Prime Movers

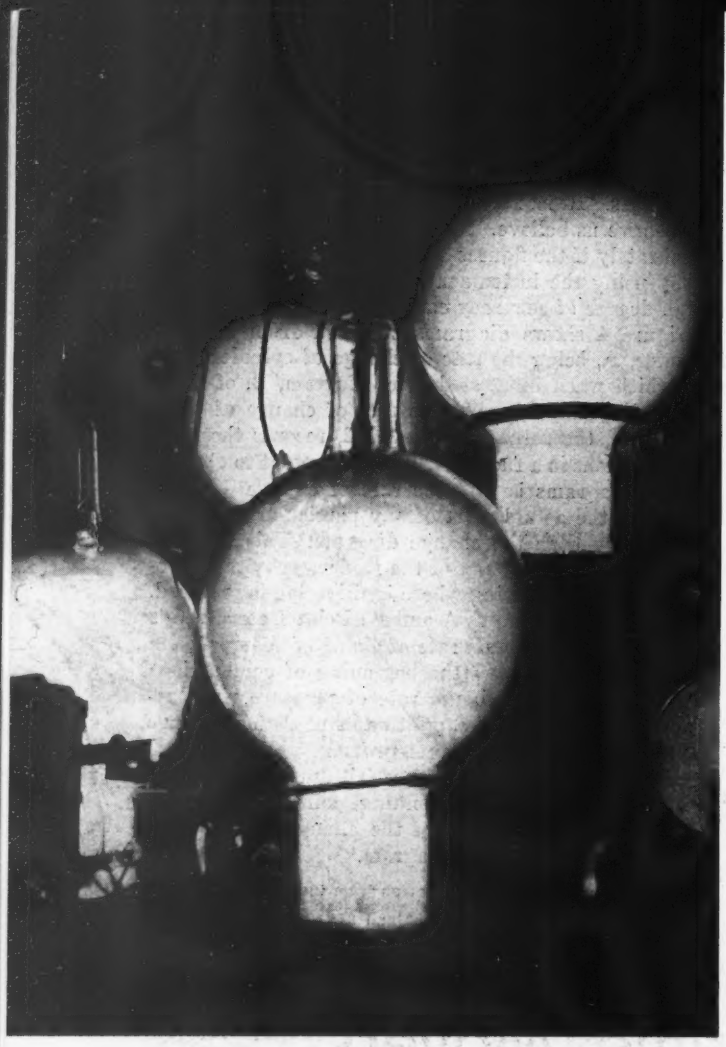
DIESELS are popular prime movers in brick and tile plants and "Dixie's Finest" the W. R. Taylor Brick and Tile Co. plant at Barth, Fla., is an excellent example of modern industrial practice. It is unusually interesting not only because of the manufacturing end of the plant but because of the variety of drives utilized.

A Fate-Root-Heath combination machine with a capacity of approximately 60,000 brick or 15,000 tile in 8 hr. is belt driven from a plain pulley by a 180-hp. Fairbanks-Morse Model 32 Diesel. The other machines are driven from pulleys on a 63 ft. line shaft connected to the engine through a friction clutch. In order to protect the Diesel from dust, it is located in a separate room, belt drive and line shaft extending through the walls.

A second 120-hp. Diesel of same make and type, drives a direct connected Fairbanks-Morse 47½-kv-a. 240 v., 3 ph., 60 cycle alternator, a belt driven exciter and a waste heat fan. This fan is driven through a chain drive, jackshaft and 36 in. friction clutch as shown by the attached photograph.

The fan is used in connection with the Minter system of kiln firing. Waste heat from burned kilns is used to preheat those to be burned resulting in considerable saving of heat and a reduction in the kiln cooling time from approximately 20 to 5 days. The small engine operates continuously for weeks.

The 120-hp. engine drives a fan, 47½-kw. generator and a 5-kw. exciter



Electron Tubes—

PART XX

BY A. W. KRAMER

THE ELECTRON TUBES so far considered, with the exception of the photoelectric tubes, have all been of the hot cathode type; that is, thermionic tubes. In these tubes the electrons forming the "space" current have their primary source in a heated filament or a heated surface coated with a substance which emits electrons at a relatively low temperature. The amount of current which can be carried by these tubes naturally is limited by the number of electrons that can be emitted by the heated cathode. In modern tubes, these currents, especially in the case of the gas-filled tubes, can be made to have large values, a hundred or more amperes in some cases, but for power applications it is necessary to employ currents of considerably greater values and if tubes are to be used with such currents it is obvious that at the present stage of the art at least a different source of electrons is desirable.

On the other hand, there are cases where exceedingly small currents are useful and if a simpler tube than ordinary high vacuum thermionic tube was available, it is obvious also that such a tube would have value.

Fortunately, tubes which meet each of the above requirements are available, and since the former at least are of great importance in the power field we shall devote this chapter to a discussion of them.

The high current tubes as a matter of fact are the oldest form of commercial tubes in existence for they are none other than the well-known mercury-arc rectifiers used in street lighting service long before electron tubes were known in the present sense of the term. In the mercury-arc rectifier, the source of the electrons is a so-called cathode spot, formed on the surface of a pool of liquid mercury by the action of the arc. The spot dances about over the surface of the mercury, its size varying with the instantaneous value of the current, but it is always an intense source of electrons.

The low-current tubes referred to above are of quite different type and form; they are the cold cathode tubes which depend for their operation on the small amount of ionization always existing in a gas. These tubes are not used very much but their action is interesting from a purely scientific standpoint and for this reason we will consider them briefly; first, however, we will discuss the pool-type mercury vapor tubes.

Mercury Arc Rectifiers

The conventional pool-type mercury arc rectifier needs no introduction to power engineers since it has been in commercial use for many years. This type of tube has a mercury-pool cathode and one or more anodes enclosed in a heavy glass bulb as shown in Fig. 1 or in the case of large units, in steel tanks, as shown by Fig. 2. The latter probably does not measure up to one's ordinary conception of an electron tube—certainly it does not look like those we use in our radio receivers but it is just as much an electron tube as the others considered in this series of articles.

Referring to Fig. 1 the large bulbous part of the tube is to provide enough condensing surface for the mercury which is vaporized from the pool by the heat of the arc which forms between the cathode pool C and the anodes A_1 or A_2. The anodes, as indicated, are fixed in the appendages extending out from the main tube, this arrangement tending to isolate the anodes from each other, thereby reducing the tendency of the current to flow from one anode to the other as a result of continuous ionization.

A rectifier of this kind is not self-starting; some means must be employed to create an initial ionization which initiates the arc. In the tube shown this is accomplished by applying a voltage between the starting electrode S and the cathode C and tilting the tube until the two mercury pools make contact. Then, as the tube is tilted back to its normal position an arc forms on the surface of the cathode pool C. This arc forms what is known as a cathode spot on the surface of the pool which serves as an intense source of electrons, and if, when this cathode spot has come into existence, potential is applied to the main anodes, A_1 and A_2, the main arc forms between them and the cathode C. In this way the main arc is initiated. Thereafter the main arc itself maintains

Principles and Applications

Tubes for heavy power applications. The mercury arc rectifier, its principle of operation and recent developments in its construction. The Igniter type of mercury arc rectifier.

the cathode spot and as long as potential is maintained on the anodes the tube remains in a conducting state. The tube de-ionizes and becomes non-conducting in a few microseconds if the potential on the anodes is removed however, and for this reason, with alternating potential applied to the anodes as is always the case in rectifier practice, the tube stops conducting after the first half cycle and requires starting again unless by some method the current can be maintained.

In some tubes this is done by providing auxiliary anodes which are energized by direct current which thus maintain an arc to the pool continuously. In other cases,

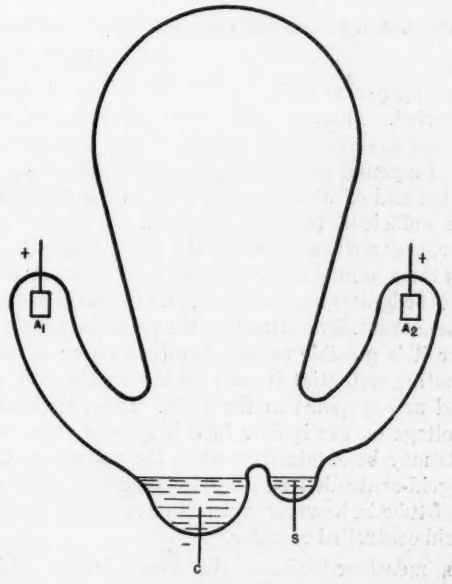


Fig. 1. Section showing the elements of the mercury-arc rectifier. In this tube the main arc is carried between the cathode pool C and the anodes A_1 and A_2. A separate starting electrode S is provided to initiate the arc at the start of each conducting period

as in Fig. 3, inductances are added in each anode circuit which cause the current in one anode to continue until the other begins passing current. The theory of the cathode spot in the mercury arc rectifier has been the subject of much discussion and considerable study but still is not fully understood. Whether the action is thermal or electrostatic or both is not entirely clear but that has made little difference in the development of the principle for commercial use.

With the mercury-arc type of rectifier, the overall size of the tube and its elements determines the ease or difficulty of evacuating the tube and maintaing a permanent vacuum. As the tube becomes larger it becomes increasingly difficult to treat the various parts so as to remove all traces of gas in the metal and glass. If this gas is not removed at the time the tube is constructed it will come out gradually while the tube is in service and thus cause failure.

Steel Tank Rectifiers

For this reason, tubes of high capacities, and rectifiers of this kind are made in sizes up to 3000 kw. or more are usually made with metal tanks in which the vacuum is maintained continuously by a vacuum pumping system. This introduces complexities in construction and operating troubles but in the case of large capacities this is justifiable.

The Grid-controlled Mercury Arc Rectifier

Tubes of this type are fundamentally diodes, and as such are simple rectifiers. As in the case of the hot cathode gas filled tube, it is possible in the mercury-arc rectifier to add a control grid between the anode and the

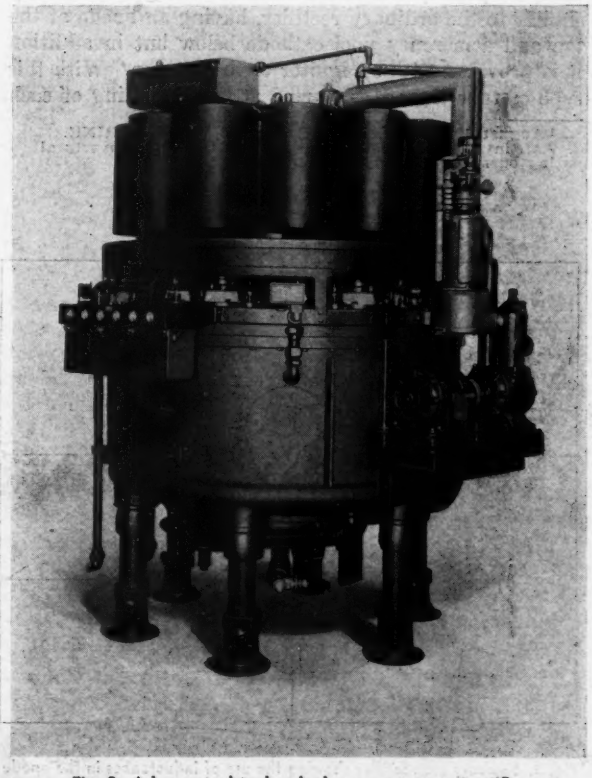


Fig. 2. A large steel tank polyphase mercury arc rectifier

cathode. The action of the control grid in this case is exactly the same as that of the control grid in the hot cathode triode or thyratron; it can only prevent the arc from starting; it cannot stop a discharge which has started. As described in the chapters on the gaseous triode[1], as soon as a discharge is started there are approximately equal quantities of electrons and positive ions in the gas space between the anode and cathode. Since the ions neutralize the electrons, there is no space charge when the discharge has started and there can be no appreciable grid-control effect. The only way to stop the discharge is to reduce the current to zero by opening the circuit or by reducing the circuit voltage. In an a.c. circuit where the voltage passes through zero twice each cycle, the grid can regain control at these times.

The manner of mounting the control grids in a grid-controlled mercury arc rectifier and the design of the grids is of course quite different from that of the hot cathode gaseous triode, mostly because of the high capacities in which these rectifiers are made but their function is fundamentally the same. The unit shown in Fig. 4 is a high powered grid controlled rectifier of this type, complete with its vacuum pumping equipment.

The addition of electrically energized grids has greatly extended the use of the mercury arc rectifier since these grids make possible voltage control under load and operation of the unit as a rectifier or an inverter[2] of power.

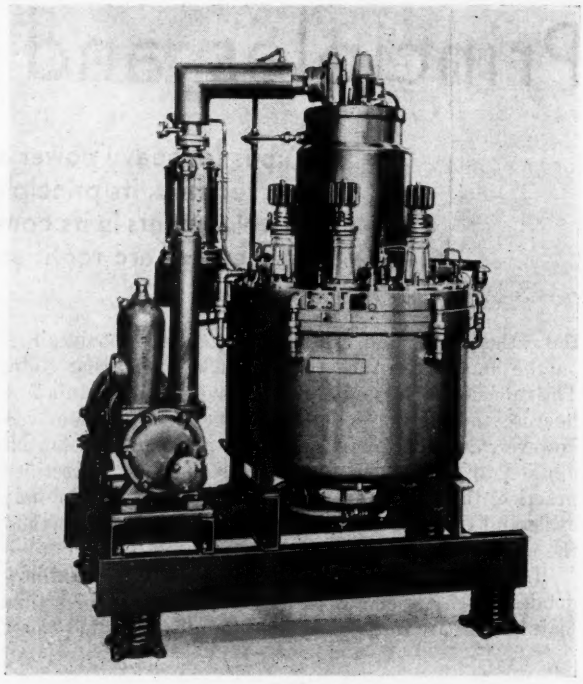


Fig. 4. A high power grid controlled mercury arc rectifier

The Igniter Tube

During the past few years, however, a new form of mercury-arc rectifier has been developed which, already, has received extensive application, especially in the control of electric arc welding. This is the igniter type of tube, the principle of which is shown in Fig. 5. It is very similar to the ordinary rectifier, having an anode at the top and a mercury pool cathode below but in addition it is provided with an igniter or arc starter. With this type of tube the arc is started at the beginning of each conducting period and permitted to go out at the end of this period. There is still some difference of opinion regarding the theory of the igniter but it consists essentially of a pencil of resistance material such as carborundum, the end of which is immersed in the mercury pool. When sufficient positive potential is applied to the igniter, tiny sparks appear at the point where the igniter enters the mercury and a cathode spot forms at the junction of the igniter and mercury, and the main anode starts to pass current. By controlling the potential applied to the igniter it is possible to turn the tube on or off when an alternating potential is used on the anode or it may be started at any point in the cycle. Thus, by controlling the voltage on the igniter in this type of tube the same results may be obtained as when the voltage on the grid of a grid-controlled rectifier is controlled. The igniter type of tube is, however, a much more simple device than the grid controlled rectifier.

As mentioned above, the theory upon which the igniter operates is subject to some difference of opinion. Slepian and Ludwig of Westinghouse who were primarily responsible for its development regard[3] the action to be the consequence of a high potential gradient at the junction of the rod and the mercury, and have advanced mathematical as well as physical evidence that such high potential gradients as are necessary can be made to exist. Others admit that though the theory of Slepian and Ludwig may be applicable to certain limiting conditions, it needs modification to apply to practical cases. According to certain of the General Electric Co. engineers, ignition in these tubes is caused by the current flowing in a narrow band of particles on the igniter surface at the meniscus of the mercury[4]. While investigating the

[1] August 1936 issue, POWER PLANT ENGINEERING.
[2] An inverter is the opposite of a rectifier, it converts alternating current into direct current.

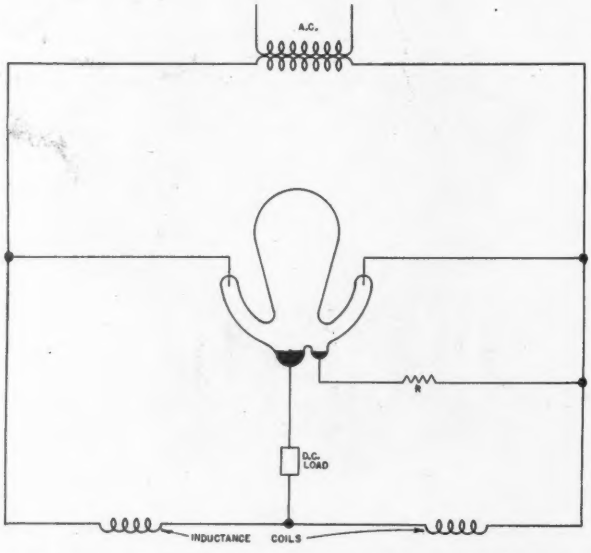


Fig. 3. Mercury arc rectifier showing the use of inductances in the anode circuit to maintain the arc

[3] A New Method of Starting an Arc. Electrical Engineering, September, 1933, page 605.
[4] Theory of the Immersion Mercury-Arc Igniter. General Electric Review, October 1935, p. 464.

effects of surface (of the igniter) conditions on starting characteristics, it was found that dull mat surfaces required lower starting current than did shiny surfaces, even though the material was identical in the two cases. When the mercury could be made to wet the igniter material, larger starting currents were required. It appeared probable from these experiments that low current starting depends upon having as poor a contact as possible between the mercury and the igniter material. Stating it another way, the surface of the igniter should consist of many fine particles which make contact with the mercury only through their edges and points.

Regardless, however, of the exact principle upon which the igniter operates, the tube today is an established success and its use is growing daily. The simplicity of its construction lends it to many applications where the ordinary grid controlled mercury arc rectifier would be too cumbersome, and the rapidity of its action has extended the scope of electric welding to a remarkable degree. In certain electric welding operations it is necessary to pass heavy currents for very brief periods of time and under controlled conditions. The igniter tube provides this control and for short intervals of time is capable of carrying relatively enormous currents.

In high-speed spot welding a current of several thousand amperes is sometimes required for a time as short as one-half cycle. No mechanical contactor could furnish such close control for such high currents but the igniter type of mercury arc meets these requirements very effectively.

Aside from its obvious advantages as a rectifier, the igniter tube has many applications such as motor speed control, theatre light dimming, voltage regulation, etc.

While the glass walled tubes are capable of carrying momentary currents of a thousand amperes or more, for heavy duty continuous service, steel tank, water cooled igniter tubes have been developed. A cross section of

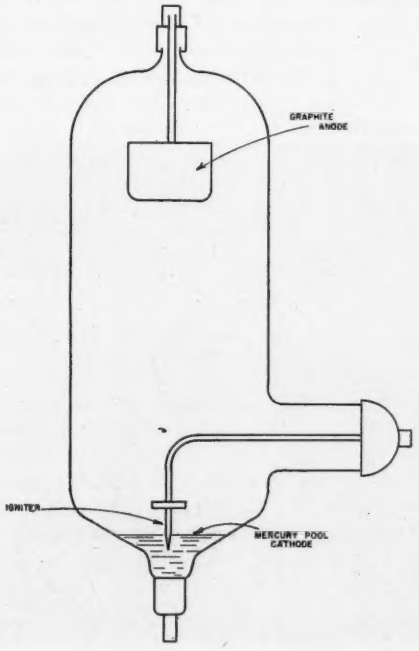


Fig. 5. The igniter type of mercury arc rectifier

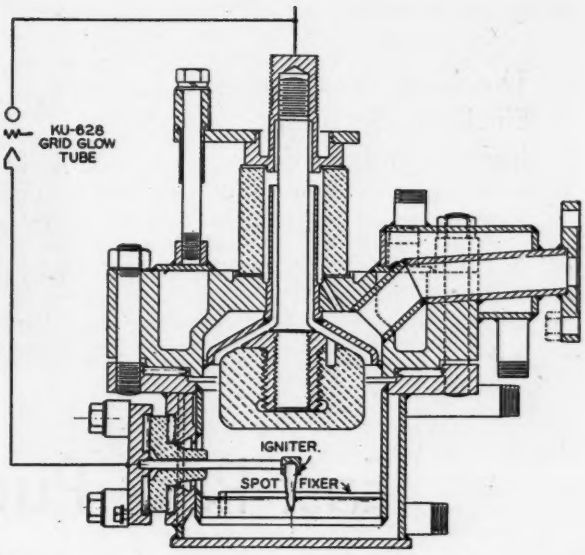


Fig. 6. A metal tank, water cooled igniter tube

such a unit is shown in Fig. 6. This tube consists of a mercury pool cathode at the bottom of a small tank of very simple design, a graphite anode insulated from the tank and an igniter electrode which is also insulated. No insulation of the cathode from the tank is required. The anode is spaced close to the cathode and no grids or shields intervene between the two. As a consequence of this close spacing, the arc drop during the conducting period is low, and at the onset of this period, the tube quickly becomes highly conducting without requiring any special system of excitation other than the igniter electrode. This electrode is of silicon carbide. Its lower end is immersed in the mercury and the upper end is welded into the holder. When current of a few amperes is caused to flow through the rod in the direction of holder to mercury, a cathode spot forms on the mercury in a few millionths of a second and the arc starts. The action of course is exactly the same as in the case of the glass tube but because of the close spacing of the elements, a higher efficiency is realized.

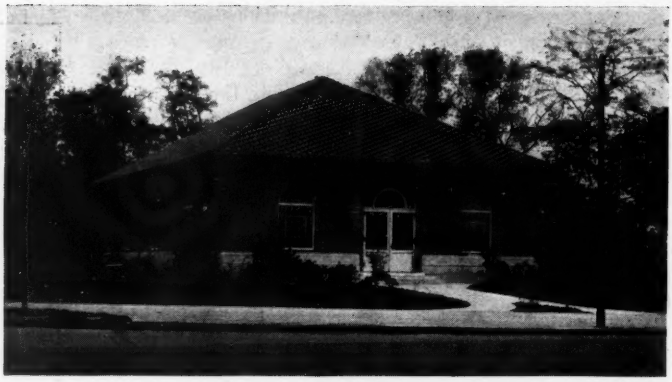
From the foregoing it is evident that insofar as the action of the igniter tube is concerned, it is essentially the same as that of the grid controlled mercury arc rectifier but is simpler. The igniter electrode in no way hinders the conduction of the arc after it has formed, whereas the grid often does so and adds about 2 volts to the arc drop.

The igniter tube is probably capable of considerable further development but in the comparatively short time since it made its appearance[5] it has received considerable commercial application.

The development of the igniter type of tube is still another example of what a more intimate knowledge of electronics is doing to the field of electrical engineering in general. It vastly extends the scope of a device (the mercury arc rectifier) which before could fulfil only one function. Today mercury arc tubes serve not only as rectifiers but also as inverters and control devices for the control of current and frequency in electrical circuits.

[5] 1933.

The Last Word in Efficiency, Simplicity, Safety and Utility



East Park Pumping Station

By JAMES H. JEWELL

Westinghouse Electric & Mfg. Co.

SAFEGUARDING the lives and health of large metropolitan populations is the everyday job of municipal engineers. No better demonstration of ingenuity and ability could be given than in the construction of the newest pumping station by the Bureau of Water Engineers under the Department of Public Works in Philadelphia. This station is known as the East Park Booster Station.

The water supply for Philadelphia is obtained from its two rivers, namely the Delaware and the Schuylkill. Despite much discussion on this subject the absolute absence of typhoid infection is proof of its purity and the efficiency of the bureau.

The entire West Philadelphia area with a population of 500,000 having a daily consumption of about 60 million gallons, is supplied by the Belmont Pumping Station and Filter Plant.

The rest of the city including Germantown, Chestnut Hill, Northeast, Downtown and South Philadelphia Sections, are supplied from Shawmont, Roxborough, Queen Lane, Torresdale and Larners Point Stations.

By careful study the East Park Station was so stragetically located and designed that it serves a threefold purpose, namely:

1st. Greatly improves conditions in the large Downtown or Central section of the City.

2nd. Supplies excess demand for South Philadelphia in extreme heat periods.

3rd. Acts as a standby for the West Philadelphia area in case of trouble at the Belmont Station.

The mechanical and electrical equipment of this Station consists of three 25 million gallon De Laval single stage centrifugal pumps, driven by 800-hp., 13,200 v., 900 r.p.m. Westinghouse synchronous motors.

The station is located alongside of a 48-in. cast-iron main feeding into the main section of Philadelphia and just above the West Philadelphia connection.

A connection to the 48-in. cast-iron main is made in a concrete chamber by a 48-in. steel suction which supplies the three (3) pumps. The pumps discharge into a 48-in. steel discharge which is connected back into the 48-in. main in a concrete chamber just ahead of the West Philadelphia connection. The distance from the suction connection to the discharge connection is approximately 150 ft.

Because of the different jobs this station must do, the engineers specified that the pumps be designed and built for the best possible performance for two different conditions, namely 25 million gallons at a 149 ft. head and 20 million gallons at a 170 ft. head, with the average overall wire to water efficiency at 82 per cent. After the units were built and installed,

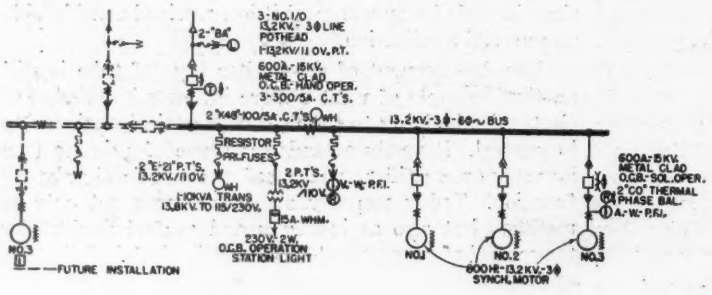


Fig. 1. Line diagram showing pumping station equipment

the actual field tests showed these units to be over 85 per cent wire to water efficiency.

The electrical equipment represents the very latest in design and manufacturing improvements as well as the last word in simplicity. All of the electrical equipment for this station was built by Westinghouse, thereby giving the city one responsibility for everything electrical in the station. At present there is only one incoming service but provisions are made for an additional emergency service, if this seems advisable at a later date. The single line diagram, Fig. 1, shows this.

The metalclad switching equipment is of the latest lift-up type, using the De-ion grid type oil circuit breaker of 150,000 kv-a. interrupting capacity. This type gives the maximum safety in operation and convenience of maintenance with the minimum of space requirements and labor of installation.

The motors are designed for across the line starting with a starting kv-a. of 420 per cent. Silicon iron is used in the motors to obtain the highest possible efficiency. The guaranteed efficiency at the time of bidding was 94 per cent, while the actual tests on the motors was 95.2 per cent. The motors are of the fabricated type of construction giving a clean cut appearance and ample mechanical strength with the least possible weight. Very definite ventilation is obtained by this type of construction eliminating hot spots and insuring the motor will give the longest possible life. The coil insulation is of mica folium and mica tape with the addition of Aquadag in the slot portion which definitely eliminates corona. Each coil is vacuum and pressure impregnated and baked at the correct temperature after each treatment.

Radio frequency high potential tests are applied to detect any weakness in insulation between individual turns in the coils thus insuring a flawless coil.

Another important feature of the motors is the damper winding which is built in sections, one for each pole, and bolted together so that any pole may be easily removed.

The bearings incorporate the latest design features

Fig. 3. Individual motor control cubicles are totally enclosed containing the necessary equipment to indicate the performance of the motors and are mounted on the pump floor near the motor

such as self-alining, length being twice the diameter, large oil reservoir, slotted top halves to insure increased lubricating effectiveness, oil throwers and neutral air chambers to definitely keep the oil and oil vapors in the bearings.

Another point of simplicity is the use of direct connected exciters which greatly simplify the control.

Individual motor control cubicles, totally enclosed and containing the necessary instrument and relay equipment to indicate the performance of the motor and to amply protect the motor from overload and under-voltage are mounted on the pump floor at the motor so that the operator practically stands along side the motor when starting.

Testing facilities are provided for testing all relays and imbedded temperature detectors with terminals mounted on the motor frame are provided for testing the internal temperatures of the motor.

Disconnecting type potheads were used at the motors to facilitate the removal of a motor if necessary,

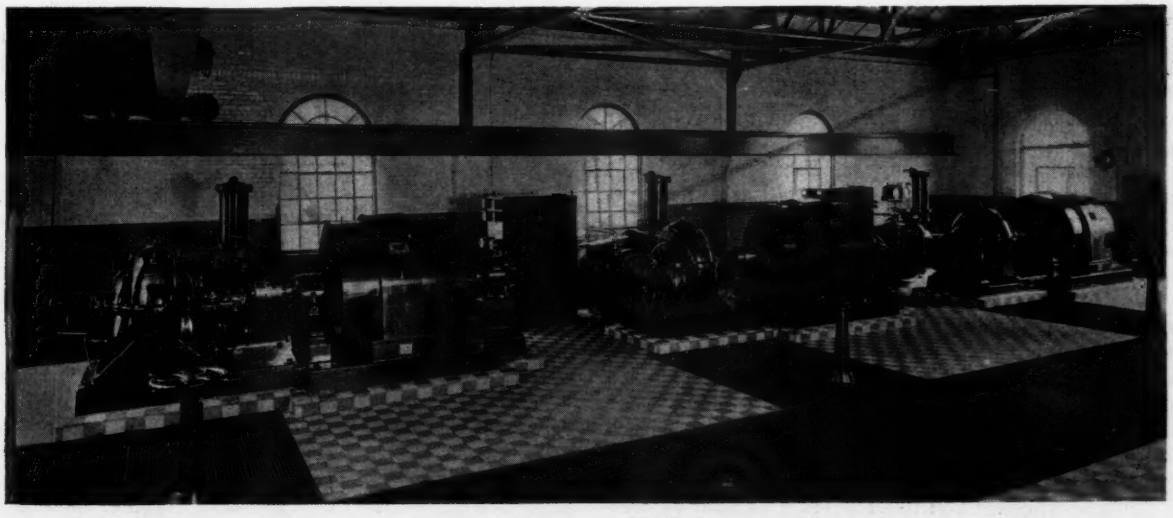


Fig. 2. Centrifugal pumps driven by synchronous motor with an 85 per cent wire to water efficiency

for any reason. There also proved a simple method of changing direction of rotation at the time of original starting.

Low voltage for lighting is obtained from a 10 kv-a. distribution type transformer, 13200/230/115 v., which is enclosed in the rear of the metering compartment and this is distributed by a Nofuze combination lighting and power panelboard.

The entire building was erected with W. P. A. Labor, the City drawing the plans and furnishing all materials. This made it possible to put all other work which included piping, excavating, foundations, installation and testing of all pumping and electrical equipment, in one contract. The contractor who was low bidder on this job was the Dravo Doyle Co. of Pittsburgh.

Particular attention was given to the interior arrangement of all equipment providing space and crane facilities for future maintenance and repairs.

The outside appearance is very attractive as the station stands practically at the entrance of the Fairmount Park and the design and construction of the building had to meet the approval of the Fairmount Park Commission and the Art Jury.

The photographs testify to the excellent interior appearance and the rugged and latest design features incorporated in all equipment in the station.

Increases Flexibility of Industrial Power Plant Small Engine

Auto engine installed to start main gas engine and give emergency lighting service

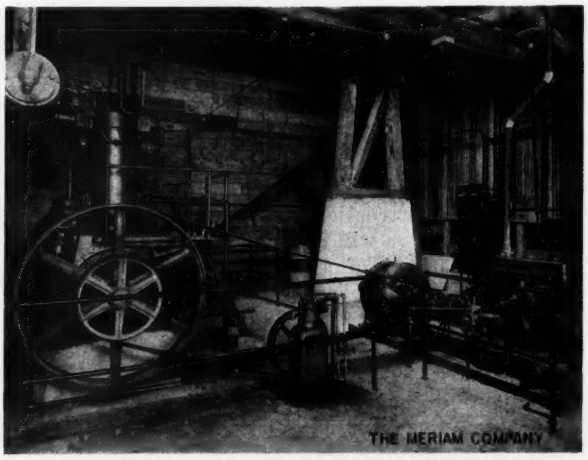
INDUSTRIAL PLANTS which have seasonable loads and short working shifts must make adequate provision for a flexible power supply in order to provide efficient operation and adequate service through peak periods as well as through the night and off-seasons when the power demand is limited to a small amount of lighting and perhaps one or two minor auxiliaries.

Recently a brick company at Houston, Tex. made an interesting addition to give a more flexible arrangement to carry a load of this kind. In this plant the load is carried by a 150 hp. natural gas engine with a shaft extension and pulley at each end. The pulley on one end is arranged to drive a line shaft and the main plant load through the usual clutch which permits the engine to be started up with no load. The pulley on the other end is solidly keyed to the shaft and is used to drive electric generator, the shaft extension to the generator being provided with a ball bearing disc-clutch pulley. A smaller pulley at this same end drives an air compressor.

This arrangement in itself offers a number of combination drives, but provides no emergency lighting service and is of course not efficient at very light loads. The addition of a Buick automobile engine rebuilt by the Meriam Co. remedies this condition and at the same time increases the flexibility of the plant. The auto engine complete with the regular automobile gearshift and coupled through a splined extension shaft to the electric generator as shown by the photograph.

For peak load conditions both the gas engine and the automobile engine may be used together to carry the plant load. At night the automobile engine is to be used to separately operate the lighting load and small pump motors. The main engine may drive both the main plant load and the generator load together or separately and finally the automobile engine may be used for starting purposes.

In the latter case the small engine is started with the gear shift in neutral. The disc clutch on the extension shaft is then engaged and the gearshift lever



Automobile engine installed in a Texas industrial plant for starting the engine or for emergency power supply

successively moved from low to intermediate and high so as to turn over the main engine and generator until the former starts firing after which the auto engine may be disconnected by shifting the gears to neutral. The generator, without excitation at low speed, requires only a negligible amount of power. As the main engine speeds up, the starting clutch is engaged to start the plant machinery and the generator may be left connected to it or disengaged as desired.

ALTHOUGH Federal Power Commission expresses its accord with provisions of an agreement entered into by Connecticut, Massachusetts, Vermont and New Hampshire for flood control of the Connecticut and Merrimac rivers, as to general purpose and division of costs, it opposes approval of the agreement by Congress on the ground that the states concerned may "provide for development by power companies or other private agencies," while the Commission wishes to retain power to "give the preference to municipalities and public power districts," apparently without regard to what course the states may consider most advantageous to their communities.

"It may be a strain on our pleasant relationship when I ask you to believe the gist of this," writes the author. "However, the boiler set-up described actually exists in a mill on the Tusket River and I am willing to accept the guide's word about the repair once effected." Well, if Pulverizer Pete can accept it, perhaps we can. We have run across cases almost as bad ourselves.

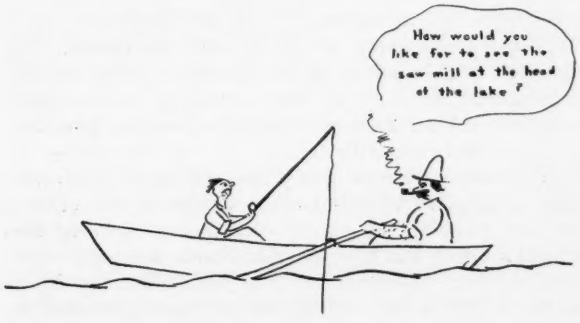
MODERN BOILER PRACTICE

By PULVERIZER PETE

RECENTLY NOT so long ago I gets my vacation which I spends in Nova Scotia which, Ed, is why you didn't hear from me for maybe a couple a weeks. So to forget the troubles of my power plant sweepin' job I gets me a guide to take me fishin' where the trout has been but ain't. This is because trouts go on an eighteen day diet every year, which eighteen days is my vacation.

So one day when the fish is doin' an extry good job of not bitin', my guide, Charley, he sez,

"Seein' as to how you is a power plant expert and the fishin' ain't so good (we been fishin' five hours without a bite—Author's note) maybe come bye'm bye you would like for to see the saw-mill at the head of the lake".



"Oke", say I and we paddles five miles up the lake and my back gets plenty sore so I guess maybe Charley takes plenty rests because he sits behind where I can't see him.

"Thar she be", sez Charley, "and by gar she one damn fine mill."

I looks at the rusty tin and wood sheds and wonders why he adds "fine". I just gotta tell you about it, Ed.

The first thing I see is a little gasoline fire engine which a guy is just gonna start up.

"Where's the fire", sez I.

"Ain't none", sez Charley, "thats for to feed water into the biler."

Charley splashes water into my face and I comes to about five minutes later.

"Explain", sez I.

"The fire engine she was got for to put out fires in the woods, but the old logging roads ain't so good so there ain't many places it can go. So they puts it on a scow for to make a fire boat which they pulls with a motor boat. This ain't so hot neither because nothin' ever catches fire by the water."

So Charley raves on and it seems I best translate the rest of it into good English like what I speaks because it is kind of hard to understand him sometimes and sometimes what Charley says ain't what should get printed.

Anyhow it seems like one day somebody starts the mill engine with a bang. The bang is because he forgets to let the water out of the cylinder first.

Now the mill boss he decides that as long as they needs a new engine it should be a little bigger because the one which is busted was a little, little.

So they gets the nice shiney new engine set up and it don't run so good because now the boiler pressure ain't high enough to run it efishently. But the boss is a genius (like you says I am) and he soon shows up with a heftier spring for the safety valve which it now holds down a higher pressure in the boiler.

Everything is jake now except the injector—that won't work. And that is how come the boss does his masterpiece with the fire engine. Now I don't like to bother so great a man with foolish questions so I don't know how much the pressure goes up but the pump puts the water in, the injector don't put the water in so they uses the fire pump. I guesses how maybe the injector was hooked up cockeyed but that's his worry.

Between you'n me, Ed, it looks like the damn fire tube job they got wouldn't hold three pounds gage.

Next I gets a cloud of smoke in my eyes and sees where they is burning a hell of a lot of bark in a big pile.

"What does they fire in the boiler?" I asks Charley.

"Straw", he sez without battin' an eyelash, "and

scraps when the clothespin factory or the farmers down river don't want none."

"Why waste the bark and go huntin' up straw?" I asks.

"What Hofft it," he sez, "neither costs nothin' and the bark she don't burn so hot."

I has one more question which I figures is important enough I should ask the boss hisself.

"How", I says in my most expert manner, "does you treat your feedwater?"

"Wal", he sez, "'ve been readin' a lot about that sort o' thing but I don't put no stock by it. Nothin' kin beat the screen I got on that suction line and I ain't never yet found nothin' bigger'n a six inch trout when the pump valves get stuck."

"Let's go back to camp", I sez to Charley.

"Sure," he sez, sittin' down on a log and pullin' out his pipe.

"Say, did I ever tell ye about how we fixed that biler once?"

"No", I invites.

"Well, one day when I had me a job o' work there; there's a little crack starts back from a rivet in the biler."

So again I'm gonna edit Charley's remarks.

Anyway, this time the mill boss pulls his piece de resistance (that's Nova Scotia for a good repair job). It seems he gets a flock of shoring rigged up and then with a mess of wedges he jams a piece of automobile tire against the crack so it stops leakin'.

"How long did it hold?" I ask, gettin' into the canoe because I figures I was too close to that fix-up job.

"About a coupl o' weeks".

"Then what?"

"Then some insurance inspector come 'round, raise plenty hell, make boss shut down. Bye 'm bye big shots come round, raise hell. So pretty soon maybe two, three weeks hell raisin' stop and a guy come 'round to weld up biler. Boss say by gar next time he won't do no favor, he won't fix the damn pot."

Detecting in the Oil Fields

When the engineer turns detective he scorns false whiskers and a magnifying glass for plain common sense and native ingenuity. The thief is replaced and 9.27 qt. of oil per crosshead is saved every month

By ELTON STARRETT

UNLESS a stream of oil, aggregating 1½ pints per 24-hr. da., was run to each of the crosshead bearings of a set of 4½ by 24 in. duplex plunger pumps, handling 56,000 barrels of crude oil per day against 800 lb. per sq. in. initial pressure, excessive heating of the bearing quickly became evident. Unless great care was taken and extra oil fed, either by opening the drip regulator or by hand oiling, the brasses and pin rapidly wore away or seized and cut seriously.

As contrasted with those at the main shaft and crank pin, lubricant fed this bearing could not be saved, centrifuged and fed again, due to contamination with crude petroleum leaking through the packing around the plungers so that flooding of the bearings without unreasonable oil bills was impossible. Although it was known that a large percentage of the oil fed was ineffective, the waste was regarded as unavoidable and the oilers went on wiping up drops spattered on the pump foundations and swabbing out the pools of oil along the lower crosshead slides. This waste continued without undue attention until one of the head office "higher-ups" paid an unheralded inspection visit and wondered, audibly, about the oil puddles.

Five of the six pumps were gear driven from Diesel units, governed to operate at 45 strokes per minute. One of the five was always down and held in reserve while the sixth pump, identical with the others, was equipped with a motor drive through variable speed transmission so as to put just enough oil into the line to maintain the maximum allowable pumping pressure at the discharge manifold.

This motor driven pump was equipped with the same type of lubricant feeding system as the others, but for purposes of experimentation (following the official's visit) was also provided with a second sight feed cut and collector, this one conveying the oil it gathered into a cup carried on a bracket attached to the head of the crosshead pin where it could be removed and a second container attached without loss of lubricant while the pump was running.

All oil put into the cup feeding this duplicate system was carefully weighed as was that caught and retained in the collector. First results tabulated on this test showed such a wide spread between amount of oil fed and that recovered that they were discarded prematurely as being somehow unreliable, and a second set of tests made. The new run corroborated the earlier findings and led to a wider investigation.

With the point of contact between the distributor wick and the collector set at 3 in. from the inner end of the crosshead travel, standard on the pumps as

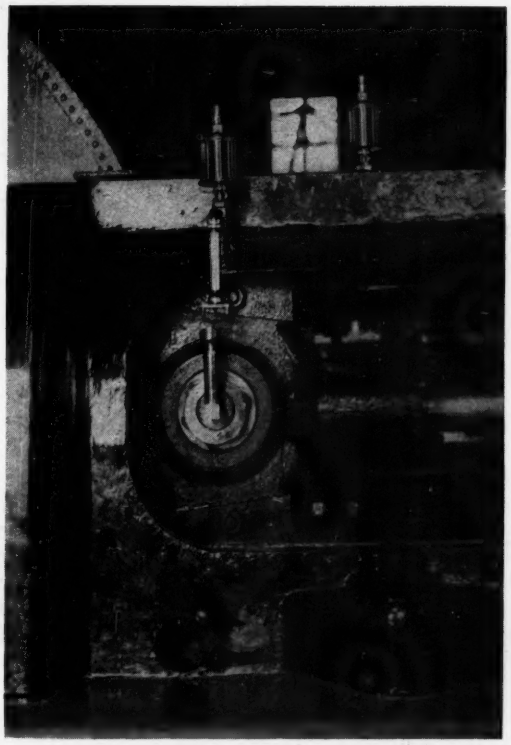


Fig. 1. This type of crosshead lubricator was found to be wasting oil at one pumping station. It was replaced by a telescopic oiler and 9.27 qts. of oil per month per crosshead was saved

turned out by the manufacturer—it was found that at normal operating speed only four-fifths of the oil fed through the sight feed reached the bearing, the other fifth being wasted through spattering or by forming into drops and falling from the wick in the intervals between contact with the collector.

To provide a check on the loss of oil through drops falling before the collector could reach them and to determine the effect of impact against the oil droplet, the point of contact was checked in four different positions: at 2, 3 and 4 in. from the end of crosshead travel, and last, at 12 in. or midway of the plunger stroke.

Figures in the accompanying table, also presented graphically in the chart, are averages from three or more runs of at least 72 hr. duration and show: the influence at lower speeds of the time interval between wipings of the wicking; and at higher speeds, of the increasing spattering effect of the impact of the collector vane edge against the oil drop forming on the under side of the wicking. As would be expected, the midway position (12 in. from the end) of the slide which affords practically evenly spaced wipings of the wicking, cuts down appreciably the loss at plunger strokes up to 15 per min. After this the speed with which the collector vane strikes and spatters the oil droplet more than overcomes the earlier advantage gained by more evenly spaced wiping intervals.

With the lubricator set near the end of the crosshead travel, as shown by the curves for the 2, 3 and 4 in. positions, the effect of both contacts of collector per pump cycle coming relatively close together is shown by the high per cent of oil loss at slow speeds when the oil has ample time to form and drop clear before the collector can make the round trip to the other end of crosshead travel and return. As the crosshead speed is either slowing to a stop or just beginning to gain momentum, impact loss is less than at the mid post. In each case, the value shown represents the combined loss, as incurred through the effects of the two variable losses.

Although curves show the break in direction of the oil loss curves to come at the 25 stroke per minute point in the three cases around normal design locations, it is probable that this would have been found to range somewhere between the 20 and 30 marks if the loss had been checked on speed increments of one stroke, instead of five. No change was made in sight feed setting during any test and no shielding was added to minimize wind loss, as this factor was or could be present in normal operating.

An interesting sidelight on false economy was brought out in the course of these tests. The wicking on the pump being used happened to be comparatively new, and even at higher speeds there was not the expected amount of oil on the foundation. By replacing this wicking with a well-worn one from another pump for comparison, it was discovered that a wick worn to half its original thickness wasted *each day* oil, which at purchase value would have provided three new wicks. This loss was traced to the worn weave which permitted the drop of oil to form more rapidly and thus fall clear before the collector could make its round trip.

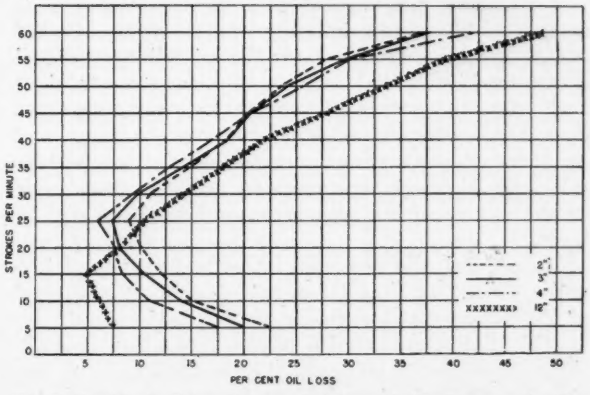


Fig. 2. Combined oil loss due to splashing and dripping as a function of speed. The different curves show the loss for wick positions at designated distances from the end of the stroke. Telescopic oilers cut the loss to 0.6 per cent

Evaluation of oil lost or wasted by the type of lubrication distribution system being used, computed for the normal operating speed of the pumps, showed that the wastage amounted to 0.309 pints of oil per crosshead per 24-hr. da., or 9.27 quarts of oil per pump per month.

Following the completion of the tests, the original sight feed lubricator for each crosshead pin was removed and replaced by a telescopic tube which conveyed all the oil fed all the way to the duct in the crosshead pin itself. Checking this system with the rig used for trying out the older equipment, established a weighed delivery of 99.4 per cent over extended runs, the slight loss being used in lubricating the joints of the tubes themselves, or dissipated through the felt wipers.

Industrial Heating and Process Furnaces*

Principles underlying direct and indirect heat exchanging furnaces

By E. F. HOLSER

INDUSTRIAL heating and process furnaces may be classified broadly as:

(I) Direct heated by combustion of fuel.

(II) Secondary or indirect heated.

The first includes principally those direct fired with coal, coke, wood, oils, gases of various kinds. The second includes those indirectly heated by means of electricity, steam, hot water, waste heat, Dowtherm, mercury, hot oil circulation, and a few other methods, of minor importance.

Direct Heated Furnaces by Combustion of Fuel

In many industrial heating processes, fuel represents only a small fraction of the total cost of manufacturing and this coupled with the fact that fuel is comparatively cheap in many parts of the United States, creates a tendency for the miscellaneous small direct fired industrial furnace to become wasteful of fuel. Also the nature of the heating operation often does not lend itself to good thermal efficiency and products of combustion must necessarily pass out at relatively high temperatures and radiation losses due to the nature of the apparatus and hook-up will be large.

In general, the principal losses in direct fired furnaces which are to a large extent under the control of the designer and operator are:

(1) High excess air for combustion. This is sometimes necessary to maintain the required limit of furnace temperatures entering the heating zone, but even where this is not the case, excess combustion air is quite likely to be present as the unseen and unnoticed thief of heat. It may result from leaky settings and doors; improper adjustment of burners, stokers, draft fans and dampers.

(2) High exit gas temperature. This condition may be inherently necessary but in many cases can be brought down to reasonable figures by proper baffling; counter-flow of gases and products being heated and proper arrangement for good radiant heat absorption.

(3) Incomplete combustion. Incomplete combustion is not common in small furnaces but may occur with hand firing or with careless adjustment of air with stokers or oil burners.

(4) Excessive radiation losses. These losses will depend much on the nature of the process and they are often inherently large, however, the proper selection and use of insulating materials will effect a worth while saving in many instances. Decreased cost of insulation materials now justifies the use of furnace wall and other insulation which formerly could not be afforded. Furnaces which are used intermittently, so that cooling down and heating up takes place frequently can reduce heat loss very materially by use of the new light weight insulating fire-brick for furnace and wall construction. In this way radiation losses when running are cut down and heat stored in the furnace walls which is lost when cooling down may be reduced to as little as ¼ to 1/6 of that with ordinary fire brick.

General factors which contribute to the improvement of the direct fired type of industrial furnace are: (1) Use the small industrial type of underfeed stoker. Where coal is the logical fuel to use, the small industrial type of stoker has unquestionably been a great factor in the improvement of furnace operation. It permits the use of cheaper sizes and grades of fuel; cuts down the attendance required; can be equipped to give automatic temperature or pressure control, approaching in convenience and usually surpassing in economy, oil or gas firing. Recent improvements and refinements in driving mechanisms and control devices make stokers trouble-free and practically automatic.

(2) Automatic temperature control instruments. The purpose of automatic temperature control is to hold the temperature required at all times. It is evident that this condition is highly desirable in most heating operations and in an increasingly great number it is becoming essential to good results. Fuel saving not alone results, but better products and less spoiled material and rejections are made possible.

(3) Insulation of walls. This has already been quite fully discussed under "Radiation losses."

(4) Preheating of combustion air. Use of stack gases to preheat combustion air for steam boilers has been generally adopted in recent years, particularly where fuel is not exceptionally cheap and pulverized coal firing is employed. The investment in preheaters is then well justified and highly preheated air is readily utilized with pulverized coal firing. Air preheaters have not been generally applied in industrial furnaces, although there are many instances where they could easily be justified. Many instances have been noted where tubular or plate types of air heaters could be used with industrial furnaces and the output utilized to heat nearby buildings. Heating of service water and the use of "Dowtherm" economizers is another method which has been proposed for utilizing waste heat in stack gases from industrial furnaces.

*Abstracted from a paper presented before the Semi-Annual Meeting of the A.S.M.E. at Detroit.

Oil and gas as fuel for direct fired furnaces, in localities where these fuels can be obtained at reasonable costs are the most satisfactory for the majority of cases. They are clean to store and handle and require a minimum amount of attention and expense to install burning equipment.

Secondary or Indirectly Heated Furnaces

Indirect heating of industrial processes is employed in a vast number of manufacturing operations at temperatures from very low up to 800 to 900 deg. F. and where electrical heat is concerned the temperatures can of course be very much higher.

Various types of indirect heating may be employed instead of direct firing to give:

(1) Lower temperatures than are readily obtainable with direct fired means.

(2) Less risk from fire or explosion.

(3) Closer temperature control.

(4) Better efficiency.

Of the several common types of indirect industrial heating, steam has undoubtedly the greatest number of applications. Many industrial plants now have steam available at pressures up to 400 lb. and a few have even higher pressures. This gives an available top temperature of roughly 450 deg. F. Pressure limitations on some types of heating equipment, however, make high pressure steam impossible or difficult to apply.

Since many good plants now have steam boiler equipment operating at efficiencies of 85 per cent or better it follows that where steam heating can be applied to industrial process it is likely to have the best efficiency and lowest cost of any heating method, either direct or indirect.

Electrical energy is a convenient and easily controllable form of heating for many industrial processes. A number of examples can be cited where a new process or product has been developed around, and depends upon the special characteristics available with electrical heating. Fundamental economic considerations, however, dictate that only those processes where the special characteristics outweigh primary heat costs, can electrical heating be justified. The best steam-electric plants today produce electricity at thermal efficiencies of 20 to 25 per cent. The mercury-steam cycle of electrical generation, when and if commercially accepted by the power industry will not exceed 35 to 40 per cent thermal efficiency. From these fundamental facts it can be seen that electric heating cannot be expected to compete with other methods for universal adoption in industry.

Electricity produced from water power where it can be developed at reasonable investment costs, is the logical current supply to use in those processes where electrical heating is imperative and location of those types of industrials at good water power sites was the natural result.

Indirect Heating With "Dowtherm"

The use of a relatively new type of indirect industrial process heating which makes use of the organic chemical compounds Diphenyloxide and Diphenyl and known under the tradename "Dowtherm" has been rapidly gaining acceptance by industry, for applications where condensing vapor or hot liquid at relatively high temperatures and low pressures are advantageous. Dowtherm vapor or hot liquid can be generated in heat absorbers similar to steam boilers at efficiencies of 60 per cent to 70 per cent and utilized for process work in a manner similar to steam or hot water heating. Saturated vapor temperatures usually range from 500 to 750 deg. F. which correspond to pressures from atmospheric to only about 135 lb. gage. Dowtherm liquid systems cover an even wider range and are also applicable to certain types of cooling. This system bridges the gap for indirect heating, from about 450 deg. F. which is the practical upper limit for steam, to 750 deg. F. which is the approximate economical lower limit for mercury vapor systems.

Heat absorbers are now offered in sizes from as small as 1 b. hp. up to several hundred b. hp. They are adaptable to use any primary fuel and can be located close to the processes they are to serve. Heat transfer rates although not as good as with condensing steam, are very satisfactory.

Pump Testing Laboratory at University of California

THE DEPARTMENT of Mechanical Engineering at the University of California has established a laboratory for the study of vertical-shaft pumps, in cooperation with the Division of Agricultural Engineering and the Division of Irrigation Investigations and Practice of the College of Agriculture and with the pump manufacturers. The work of this laboratory will include:

1. Research in the field of deepwell and propeller pumps.
2. Analysis of laboratory and field methods of testing, development of testing standards and calibration of testing instruments.
3. Tests of motors, bearings and auxiliary equipment.
4. Tests of manufacturers' types.
5. Acceptance tests of specific pumps.

Initial projects are: Accuracy of Methods of Measuring Water; Normal Characteristics of New Deepwell Pumps; Friction Losses in Riser Columns; Friction in Bearings; Effect of Wear on Pump Characteristics; Pump Thrust Loads; Development of Pump Testing Code.

Arrangements have been made to borrow pumps and accessories for carrying out this program. Manufacturers interested in participating in this work should write to Professor M. P. O'Brien, Department of Mechanical Engineering, University of California, Berkeley, California.

Discussion and analysis of capacity of chimneys by E. C. Bott in Engineering of London gives a chimney gas temperature 500 deg. F. above atmospheric temperature as producing maximum draft but the decrease in capacity with decrease of temperature difference is slight down to 212 deg. F. difference, where capacity is 0.9 the maximum. Further decrease in difference results in rapid decrease in chimney capacity, which is the reason for difficulty in maintaining draft when flue gases are wasted.

Performance of Underfeed Stokers

Use of performance curves as a guide to selection of coal and draft equipment

By JULIUS BRODSKY

LOCATING and correcting trouble arising in the operation of a power plant or of any of the component units thereof can be much simplified by a careful study of existing conditions and by comparison of the performance of the equipment in question with similar equipment operating satisfactorily.

Since every individual piece of equipment has its own peculiar operating characteristics, a performance chart may be constructed showing the relationship of those variable factors that affect operation. Such charts are available from the equipment manufacturers, and are also published in standard text books and from time to time in the current technical literature from data obtained in actual plant operation.

Checking the performance of any unit by means of such information that is thus made available will usually help to locate the source of trouble.

The particular installation to which this article has reference, consisted of two 250-hp. water tube boilers each equipped with a multiple retort underfeed stoker, forced draft being supplied by a single engine driven fan, and which presented the following operating difficulties:

1. Inability to carry load and maintain desired steam pressure.
2. Excessive fuel consumption.
3. Smoke nuisance.

Mid-west bituminous coal was used, no consideration being given as to size, quality, heat value or ash content; the price per ton being the only factor considered.

The load varied between 10,000 and 25,000 lb. of steam per hour, being made up of the process steam requirements together with the major portion of the power needed, this being furnished by a Corliss engine of ancient vintage which was considerably overloaded and thus highly uneconomical.

When the steam demand became high, in order to continue operation it became necessary to open up the fire with a bar and level it off with a rake; this procedure was partly responsible for the high fuel consumption and produced the smoke nuisance.

A casual survey pointed to the use of an unsuitable grade of fuel and an insufficient air supply to maintain the desired combustion rate; it was desired, however, to have some concrete evidence to substantiate this assumption. A hypothetical performance chart for the boilers was constructed, making use of all of the available literature on the subject and adapting it as nearly as possible to the boilers in question. Since the wind box pressure is a function of the fuel bed resistance and the combustion rate, and as the fuel bed resistance varies with the grade of fuel (per cent of fixed carbon and ash) as well as the amount of fine material and dust present, two curves were plotted for this item, one showing the wind box pressure necessary when a suitable grade of fuel is used, which is marked "good" and the other showing the pressure necessary for a poorer grade which is marked "poor."

The operation of the boilers was checked with this performance chart and with due allowance for the quality of the fuel used, it was found that the actual performance of the boilers followed very closely its predicted performance up to the point where operating troubles developed.

A characteristic curve (not shown) was plotted for

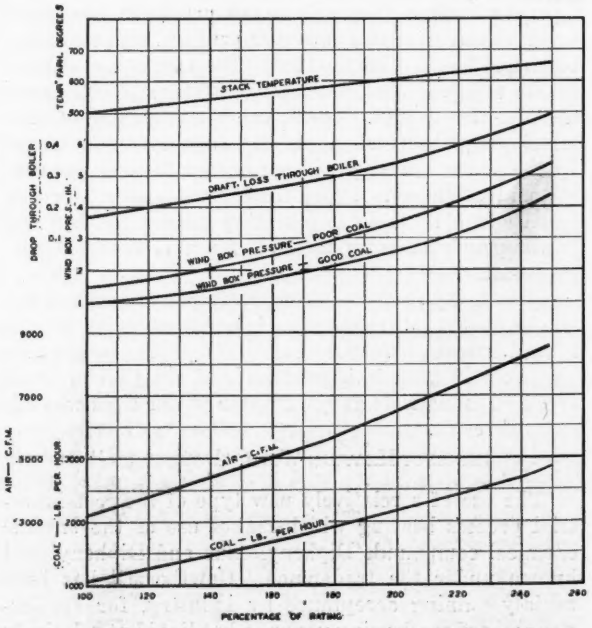

STACK TEMPERATURE
DRAFT LOSS THROUGH BOILER
WIND BOX PRESSURE — POOR COAL
WIND BOX PRESSURE — GOOD COAL
AIR — C.F.M.
COAL — LB. PER HOUR
PERCENTAGE OF RATING

Fig. 1. Performance chart of a 250-hp. water tube boiler served by a three-retort underfeed stoker

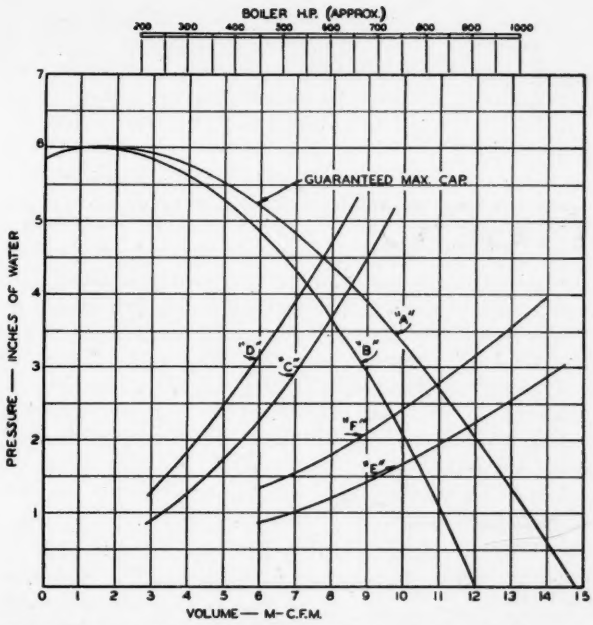


Fig. 2. Pressure-volume and pressure-boiler capacity curves with good and poor coal of forced draft fan

the stack and this was compared with the uptake draft as shown on the performance chart, this showed that the stack was ample for the requirements. Also a characteristic (pressure-volume) curve, Fig. 2, was plotted for the fan from data supplied by the manufacturers. It will be noted by studying this curve, that as the quantity of air delivered increases, the pressure decreases, this being true of all fans in a more or less marked degree. Since this pressure-volume characteristic of the fan shows only the pressure available at the fan outlet for different volumes of air delivered and this air must pass through a duct having one or more turns and other frictional resistance and possibly some leakage and since pressure loss varies as the square of the velocity in duct, some allowance was made for this pressure loss and a second curve showing the air pressure available in the wind box was plotted.

It will also be noted from the performance chart that the wind box pressure or the pressure necessary to force the required quantity of air through the fire increases as the quantity of air delivered increases.

Accordingly two sets of curves were plotted showing the pressure-volume characteristics of the fire, one set showing this relation with one boiler in operation with good and poor coal, and the other set with two boilers in operation.

"A" shows the P-V characteristic of the fan plotted from data supplied by the manufacturer, and represents the pressure available at the fan outlet.

"B" represents the pressure available in the wind box and is plotted by deducting from "A" an amount representing the friction and leakage losses.

"C" and "D" represent the pressure required in the wind box at various ratings with one boiler in operation when good and poor coal is used respectively. "E" and "F" represent the pressure required in the wind box with two boilers in operation with good and poor coal.

These curves show that the guaranteed capacity may be reached with one boiler with an inferior grade of fuel and still have a small amount of leeway till the danger point is reached, and that about 75 hp. more may be developed if a high grade of fuel is used.

With two boilers in operation (or with one boiler and double the grate area) the output may be increased to 675 hp. with poor coal and 725 hp. for good coal.

Since the load at times reaches a maximum of 800 hp., the need of breaking up the fire to decrease the fuel bed resistance and allow the passage of a sufficient quantity of air, is apparent.

These curves were superimposed on the fan characteristic, and with due allowance for duct friction and leakage it was predicted that before the point was reached where the drooping fan characteristic crossed the rising fire characteristic, trouble would develop and operation could not continue unless unusual steps were taken, and as long as there was an excess of pressure over that required, satisfactory results would ensue.

By actual observation of the operation of the boiler it was noted that when this point was reached it became necessary for the fireman to open up the fire with a bar, thus reducing the fuel bed resistance and allowing a larger quantity of air to pass through; by this means he could continue to handle the load, but this action was the cause of the smoke nuisance and was not productive to economy.

It was therefore apparent that not only was the fuel unsuitable for this type of stoker but the fan was entirely too small for the duty imposed on it.

After progressing this far, the original specifications for the installation became available, and it was noted that the fan was guaranteed to deliver 6500 c.f.m. at 5 in. pressure at 960 r.p.m., which would correspond to the operation of one boiler at 200 per cent rating, thus confirming the above findings.

This left the management with three ways of correcting the trouble:

1. Purchase of a uniform grade of fuel of high quality and suitable for this type of stoker, which would only partly help.

2. Purchase of a larger forced draft fan with a characteristic such that under the most severe operating conditions the pressure available would be in excess of that needed to overcome fuel bed resistance.

3. Or finding some means of reducing the load on the boilers, either by the use of a larger and more efficient power unit or the purchase of power.

The management being committed to a policy of following the path of least resistance, could not see the wisdom of purchasing new equipment or a better grade of fuel, consequently the major portion of the power load was taken over by the local utility.

The Chevrolet-Forge High Pressure Plant

PLANT WITH two 170,000 lb. per hr. 625 lb., 725 deg. F. pulverized coal fired boilers and one 7500 extraction-condensing turbine was described in an article beginning on page 516 of the September, 1937, issue of Power Plant Engineering. We regret that the name of Albert Kahn, Inc., Architects and Engineers, was inadvertently omitted from the text and list of equipment.

Economical Boiler Load Distribution

Boiler Efficiency characteristics determine the proper boiler to choose and the portion of load each boiler should carry to result in highest overall boiler plant efficiency

By ZUCE KOGAN

CONSULTING ENGINEER
CHICAGO, ILL.

KNOWLEDGE of characteristics of individual boilers and the combination of these characteristics when the boilers are operated together at various loads, is important in laying down rules and methods for operating a steam plant at highest economy. The general range of boiler efficiency at various loads for a given type of boiler is well known and it follows a routine pattern. The efficiency of an H.R.T. boiler for instance, rises rather steeply from no load to about 50 to 60 per cent of boiler rating. Then the rise is rather gradual and it usually reaches a maximum between 90 and 120 per cent after which the drop may be either gradual or abrupt depending on the type of boiler, the draft available, and the coal used. In spite of this routine pattern of the range of efficiency of an H.R.T. boiler each individual boiler has one or more deviations from the general trend. It is this knowledge of the specific variations of the individual boilers and especially the combined variations of several boilers when operating together under various loading conditions, that is valuable for determining what load to carry on each boiler, to meet the total steam demand at highest efficiency.

These individual characteristics together with the combined characteristics of several boilers when operated together show when it is more expedient to operate one boiler, when to operate another, and when to operate more than one boiler. With this knowledge it is also necessary to know the approximate amount of coal it takes to start an extra boiler, how much coal is wasted by allowing a boiler to run out, and how much coal is consumed in banking for periods of varied duration. The case that follows will illustrate the economies in plant operation brought about by the knowledge of the characteristics discussed above.

Plant Equipment and Methods of Operation

A manufacturing establishment was considering the enlargement of its steam facilities and we were called in to advise the necessary changes on steam generation and utilization. In the boiler plant of this concern there were 2 H.R.T. boilers, one stoker fired and the other hand fired. The stoker fired boiler had a rated capacity of 125 hp. and the hand fired boiler had a rated capacity of 100 hp. These boilers were used for both heating and process steam and the load was highly fluctuating. During the winter day time the load on the boilers varied between 160 and 240 hp. At night the load dropped to between 40 and 80 hp. depending on the weather. During the milder heating months the load was around 120 to 180 hp. and no heat was supplied at all at night and the boiler was shut down. In the summer months the load would drop to between 60 and 100 hp.

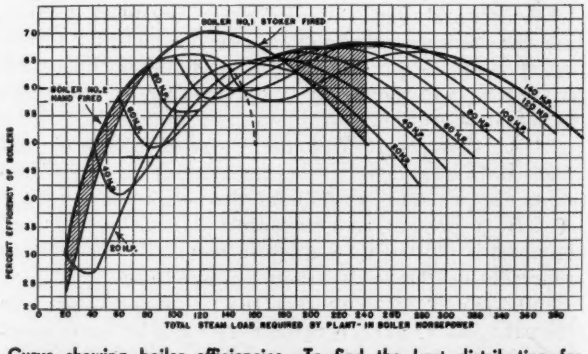
Inasmuch as the one boiler was equipped with a stoker large enough to handle all the load that was required under the conditions which then existed, only this boiler was operated steadily. In fact when the engineer of the concern asked what we thought of this method of operation we told him that off-hand it appeared to be a sensible way of operating since by operating one boiler he avoided the starting of another boiler, saved the coal that is usually lost when running out the other, and reduced radiation losses. When we began to check the overall boiler plant efficiency, however, we had to reverse our opinion.

Efficiency of Operation

A series of tests was run on both boilers to determine their individual characteristics as shown by the efficiency curves. The curve of the stoker fired boiler follows a routine pattern of an H.R.T. boiler. It begins to drop steeply after about 130 per cent of rating and naturally during the winter months when the load was heaviest, good results were not obtained because operation was taking place at the low end of the efficiency curve.

Effect of Load on Efficiency of Operation

Inasmuch as the study of this plant occurred during the winter months when there was a heavy load on we had the opportunity of determining what effect carrying the load on both boilers would have on the combined efficiency. A definite load was maintained on the hand fired boiler and the difference was taken up by the stoker fired boiler. The load on the hand fired boiler was progressively increased to as high as 140 hp. at which point the hand fired boiler could not carry any more load. During these variations of the loads we observed the combined efficiencies. As can be seen from


BOILER NO.1 STOKER FIRED
BOILER NO.2 HAND FIRED
80 H.P.
PERCENT EFFICIENCY OF BOILERS
TOTAL STEAM LOAD REQUIRED BY PLANT- IN BOILER HORSEPOWER

Curve showing boiler efficiencies. To find the best distribution for a given load locate, at the intersection of the heavy curve and the desired load, the constant curve giving the highest efficiency. This shows the load to be carried in the No. 1 boiler, the balance of the load to be carried on the No. 2 boiler. In the crosshatched areas the duration of the load and the coal used in starting up the second boiler as explained in the text

the curves the best results were obtained on the average load of 220 hp. when the hand fired boiler was delivering 100 hp. and the stoker fired boiler 110 hp. At this point the efficiency was between 67 and 68 per cent against the 55 and 56 per cent for operating one boiler.

Having the individual characteristics of both boilers we checked for the calculated efficiency of the combination of the two boilers at various loads and found that the results we obtained during the test followed very closely those calculated. Since we obtained during this test sufficient points which followed the calculated results very closely, we were justified in taking the original curves of the individual boilers as obtained and calculated for the combined efficiencies of the two boilers on the various loads. The results of these calculations are shown in the accompanying chart. In this calculation we have assumed first that the hand fired boiler delivers a constant load and that the stoker fired boiler delivers the rest, and have plotted the points to indicate the combined efficiency on the various loads.

Object of Chart

This gave us a group of curves which indicate the best operating conditions for both boilers and for each individual boiler. Inasmuch as larger loads were anticipated this series of curves would also help the engineer to determine how, and to what points, he should load the individual boilers.

Armed with such a curve the engineer has an exact view of the boiler condition. It tells him for instance, that when his load varies between 200 and 240 hp. it is best to operate two boilers. It also tells him what the loading of each boiler should be. All the engineer has to do is to know his total load and knowing this he can easily find what the hand fired boiler load should be if he desires to obtain the highest efficiency.

For example, at 240 hp. he finds that the highest efficiency is obtained when he operates the hand fired boiler at 100 hp. which means that the stoker fired boiler should assume a load of 140 hp. If he operates at any other combination the combined efficiency will be less. The chart also tells him that if he operates the stoker fired boiler alone he experiences a drop in efficiency of 16 per cent which is equivalent to a loss in fuel of 25 per cent. It further tells him when a load drops between 60 and 80 hp. that it is best to operate the stoker fired boiler, and when the load is less than 80 hp. it is best to operate the hand fired boiler.

Knowledge of the amount of coal consumed by either boiler for starting, for running each boiler out, and also for banking is important when a load hovers between 180 and 200 hp. At these points it becomes questionable whether to run one boiler or to put on another boiler. The curve tells the engineer that if he operates one boiler at 190 hp. he will experience an efficiency of 63 per cent. If he operates two boilers and carries 80 hp. on the hand fired boiler and 110 hp. on the stoker fired boiler he will experience an efficiency of 67 per cent. The latter is a saving equivalent to 6 per cent. That however means starting an extra boiler which will have to be run out at night. During the course of the day, to generate that load, he will burn 3.5 t. of coal if one boiler is operated and 3.2 t. plus the coal required for starting and the coal lost in running out the stoker, if he runs two boilers. During a previous test we found that it required 400 lb. to start a boiler and that our client lost the equivalent of 200 lb. of coal when the boiler was run out. In other words if two boilers were operated under such load conditions the same 3.5 tons would be required during the day. It is quite obvious that under such conditions it pays to operate one boiler even though at a slightly lower efficiency, as the consumption of coal remains the same but the exertion required of the fireman is considerably reduced.

Findings of the charts were borne out in practise. The steam consumption was increased by approximately 17 per cent without increase in the coal consumption and simply from a proper utilization of the knowledge of the individual and combined characteristics of the boilers.

Coal Marketing Under the Guffey-Vinson Bill*

PURPOSES of the bill are regulation of sale and distribution of bituminous coal to stabilize prices, do away with unfair competition and ensure like treatment of all consumers. The means is a commission of seven members of which Charles F. Hosford, Jr., is chairman, with 23 district boards of 3 to 17 members and a statistical bureau in each district.

For price regulation the country is divided into 10 minimum price areas and the commission is to determine for each area a weighted average cost, the minimum selling price to be set so that it will return approximately cost on each grade and size with a just profit on investment. These prices will be set for sales at the mine as quickly as possible, but probably not before Fall. Meantime, no producer may make a contract for over 30 days from date of the contract.

Marketing agencies of producers, to be approved by the commission, must show that they effect no unreasonable restriction of supply, will not prevent sale to the public at reasonable prices, or operate against public interest. They will be allowed to market coals of producers to best advantage, to prepare statistics on the movement of coal and market trends, to advise producers as to prices and to show the public how to use coal efficiently. All these have already been pioneered by Appalachian Coals, Inc.

Dumping at low prices, of grades which are not selling rapidly, will no longer be allowable, so that an exchange department will be needed to bring the distribution of grades into balance. Other activities of agencies such as A.C.I. will be institutional advertising, engineering service, and aid to producers and customers.

Producers will be guaranteed protection against price cutting but must eliminate secret rebates or allowances, prepayment of freight, credit discrimination or discounts to any purchaser that are not allowed to all others.

Mr. Howe advanced the idea that retailers covering given areas, while they do not come under provisions of the bill, might well set up organizations to establish a fair margin of profit on all coals, to effect exchanges of grades as desirable and to aid customers in efficient use of fuel.

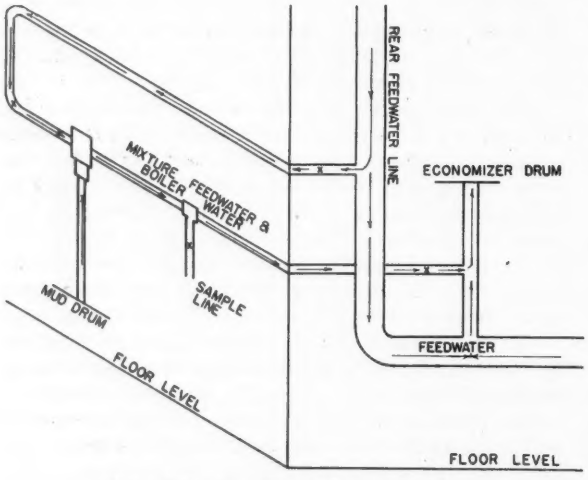
*From an address by R. E. Howe, vice-president, Appalachian Coals, Inc., before American Retail Coal Association.

Readers' Conference

Removal of Dissolved Oxygen

HAVING ADOPTED the use of a commercial sodium sulphite at the Alameda Street team plant of the Bureau of Power and Light of the City of Los Angeles, for the removal of dissolved oxygen in the boiler feedwater, it was later found that, due to having economizers in our boiler settings, the chemical was not being oxidized very rapidly and consequently not performing its function.

Due to the fact that we did not have a continuous feed system for treating the feedwater before it was fed to the boilers, each boiler was treated individually and as a result the injections of the chemical



Piping Setup for a Boiler Water Recirculator

passed through the economizer drums doing very little good and arriving in the steam drums, where it stayed, picking up traces of the dissolved oxygen until after several weeks it was completely oxidized.

During this time the greatest percentage of the dissolved oxygen in the feedwater was oxidizing the economizer surfaces and from inspection it was found that the chemical was of very little help in preventing oxidation of the metal.

Due to the uncertainty of operating conditions it was not thought advisable to install a continuous feed system which would treat the feedwater with sodium sulphite before it was fed to the boilers and in that way remove almost one hundred per cent of the dissolved oxygen.

It was decided to install a so-called boiler water recirculator, which would enable us to utilize the differential between the boiler and feedwater pressures to operate a jet pump which would pull the boiler water from the mud drum and mix it with the incoming feedwater which was to be used to operate the jet. After experimenting with different sized jets one was found that operated satisfactorily and the recirculator was installed on one of the boilers.

Tests were made of the mixture of feed and boiler waters and it was found that there was approximately 20 per cent recirculation of the boiler water. This was immediately apparent, as the consumption of the chemical increased correspondingly. Changes in operating conditions caused the percentage of recirculation to vary somewhat and 20 per cent was found to be about the average for all conditions.

The minimum number of valves and pipe bends was found to decrease materially the pressure loss due to friction and in the case of low pressure differential, a straight pipe connection from the feedwater line to the jet pump will give the maximum differential.

At the present time there are six of the recirculators in operation at this plant and all are operating satisfactorily.

The piping set-up is very simple and the sketch shows.

Los Angeles, Cal. W. M. HAGUE.

The Flue Gas Storm Returns

IT WAS quite surprising to me to note, in the September 1937 issue, page 555, an article by Henry Cooney in which he refers to an article of mine in the July 1, 1930, issue wherein I referred to certain formulas for computing maximum CO_2 and excess air for various fuels. Mr. Cooney questions the accuracy of the formula for computing maximum CO_2 and states that the Bureau of Mines advised him this formula was only applicable to fuels containing high percentages of carbon and was "entirely unsuitable for gases containing hydrogen or hydrocarbons". This amazing opinion was given by H. H. Storch, Supervising Chemist on November 13, 1933.

Going back to my 1930 article, the formulas I gave were developed by A. A. Bato and their derivation was given in a paper entitled "Flue Gas Computations" and published in Mechanical Engineering, Vol. 48, No. 4, April, 1926, pp. 330-336. Power Plant Engineering published an abstract giving the essential features of this paper in the August 1, 1926, issue. Mr. Bato most certainly developed his formulas for fuels containing hydrogen as well as carbon. He first considers the combustion of a fuel containing carbon only as a combustible constituent, such as charcoal or coke, but he does not stop there. He goes on to say:

"The cases enumerated above represent but a few of those met with in practice, as mineral coal, oil or its derivatives, and gas fuels contain combustible hydrogen in addition to carbon. Of the fuels generally used, anthracite contains the least amount of hydrogen. The bituminous coals contain greater percentages of hydro-

gen and still more is found in crude oil, the quantity in the distillates increasing with a lower boiling point. Of the gases, marsh gas, or methane, has the highest percentage of hydrogen, twenty-five per cent of it in weight being hydrogen, whereas anthracite contains less than one per cent."

Mr. Bato then proceeds to develop a formula for maximum CO_2 based on an ultimate analysis of the fuel and says:

"The formula shows that the maximum of CO_2 obtainable depends in the case described only on the ratio of hydrogen to carbon contained in the fuel and is characteristic for this ratio."

Following this formula Mr. Bato develops one based on flue gas analysis which is given as follows:

$$CO_2 \text{ max.} = \frac{21K}{21 - O_2} \qquad (4)$$

Referring to this equation Mr. Bato says:

"If the products of combustion of any fuel are analyzed and the percentages of CO_2 and O_2 determined, it is possible to find CO_2 max. of this fuel with the aid of Equation (4) without requiring a chemical fuel analysis." Note that Mr. Bato says "any fuel".

Where carbon monoxide is present Mr. Bato has modified the formula essentially as I gave it:

$$CO_2 \text{ max.} = \frac{21\,(K + k)}{21 - O_2 + 0.395k} \qquad (4a)$$

where,

K = actual CO_2 in the flue gas sample
k = actual CO in the flue gas sample
O_2 = actual O_2 in the flue gas sample

Besides the formulas Mr. Bato developed charts which may be used to calculate the excess air and from that to determine heat loss corresponding to various percentages of excess air. In explaining one of these charts, for one of the lines giving 100 per cent excess air, Mr. Bato says:

"The loss per 100 B.t.u. and 1 deg. F. will be 0.01926 when burning carbon, and 0.01348 when burning hydrogen. For various mixtures of the two this quantity, called B, is shown in Fig. 2 on the corresponding lines of CO_2 max."

In addition to giving examples of the use of the formulas and charts for coal and oil firing, Mr. Bato says:

"The diagrams may be used for natural gas containing not any, or only a little, nitrogen, with an error according to the percentage of this gas, the error increasing in proportion of the content on nitrogen. Producer gas, blast-furnace gas, and the gas coming from a by-product coke oven, containing more or less carbon dioxide, much carbon monoxide, and nitrogen, require, however, special calculations and diagrams, which, once established for a certain type of fuel, may give very good service in the every-day routine in controlling the economic operation of the plant.

Does all of this indicate that Mr. Bato's formula is only applicable to a fuel containing no hydrogen?

Where an ultimate analysis of a fuel is not known and is difficult to obtain or calculate, as in the case of gaseous fuels, if an accurate analysis of the flue gas is obtained, the maximum CO_2 can be calculated by means of Mr. Bato's Formula 4a. However, the value of the O_2 must be checked very carefully. Mr. Bato says:

"The error most frequently encountered in actual practice is a too low reading for the percentage of oxygen in the gases."

It is quite possible that Mr. Storch arrived at his erroneous conclusion for this reason.

In a great number of cases where the ultimate analysis of the fuel was known, especially with oil and gas firing, I have found that Mr. Bato's Formula 4 checks very closely with his formula based on ultimate analysis. It also checks with values arrived at by using regular combustion formulas. I, therefore, fail to see the reason for Mr. Storch's arbitrary statement.

Chicago, Ill. J. R. DARNELL.

Success in Engineering

TWO VERY INTERESTING communications on the subject of success (or lack of success) in engineering, were published in the August issue, one from N. T. Pef, and the other from L. M. Duryee.

Philosophically, I am inclined to agree with the conclusions of Mr. Pef. The art of being happy though broke, is well worth cultivating. I do not say this in any spirit of levity. I really mean it, on the other hand, there appears to be no doubt that most of us are faced with the quite obvious duty of dealing with the problems of physical existence as effectively as possible, and it is very easy to get into the habit of kidding ourselves that failure to gain a satisfactory reward is not due to our own mistakes.

Of course, in the last analysis, the whole thing hinges upon the conclusion which we may reach as to the ultimate goal of existence. I find that most people do not seem to have come to any conclusion about this very important matter, though many of them are unwilling to admit it.

Mr. Pef is apparently of the opinion that the metaphysicians have found an answer. Of course that is what the best of them are trying to do. How far any of them have been successful is a matter of individual opinion. After all, the philosophy that satisfies the individual is the only one that is of any practical use to him.

Bergson said that to analyse a thing is to express it in terms of something other than itself. He might have added that in order to make our analysis intelligible, we must make it in terms of something with which we are already familiar. Aside from that our choice of terms is practically unlimited.

Power Plant Engineering is essentially interested in the analysis of problems in terms of engineering and allied science. That is, in objective and not metaphysical terms, and in this connection, I think that Mr. Duryee has made a very valuable contribution.

I have long been of the opinion that engineers as a class have been too neglectful of the art of salesmanship, which at its best, is largely the art of getting along with, and making a favorable impression upon one's fellow men.

Mr. Duryee's suggestion that all young engineers should take a turn at selling is excellent, though in some cases it may be difficult to follow. This is also true in the case of the older men.

Unfortunately there has grown up a somewhat prevalent idea, in the engineering profession, that salesmanship, at least as far as one's own services are concerned, is undignified if not actually unethical.

Of course salesmanship in any line may be made both undignified and unethical, but on the other hand, it may be made the vehicle of valuable service to mankind.

An engineer does not only deal with machinery, he deals with men. Even if he is a draftsman or designer and has little executive authority, still he is a unit in an organization which, if its existence is justified at all, exists for the benefit of humanity. If he thinks that his relationship to his fellow men, and to the organization as a whole, is not important, and that the establishment and maintenance of right relationship is not of real value and worthy of reward, he is, in my opinion, mistaken.

This is the real lesson that salesmanship teaches, and Mr. Duryee is quite right in emphasizing the value of it. Actual experience in selling is of great value, but even if in certain cases it is not possible to obtain this experience, that is no reason why the engineer should not wake up to the fact that he really has something to sell, and it is up to him to sell it, and not wait around expecting someone else to do it for him.

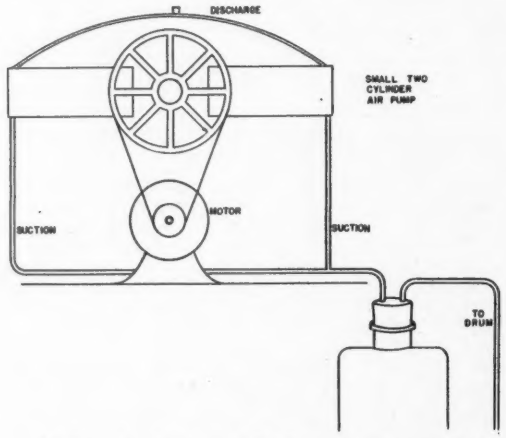
Getting "High Hat" and talking about the dignity of the profession is no excuse for refusing to view the problem in its broadest aspect. Failure to take into account all the factors of a problem lies at the base of all faulty engineering.

Bloomfield, N. J. JAMES O. G. GIBBONS.

Useful Gadgets

IN A SMALL and somewhat isolated institution it often becomes necessary to invent equipment and devices not otherwise obtainable. I am describing three such devices or "gadgets" which have done a great deal to simplify some of my many problems.

Our alcohol comes in metal drums. Our storage space is limited and we store the drum on end. For years it was the practice to siphon out the desired amounts of alcohol. This meant a miserable time for the person who created the initial vacuum and who invariably gagged and choked on a mouthful of "190 proof" liquid fire. In our large collection of discarded apparatus and junk, I found a small pump which had been used for various emergency purposes, principally in "T and A" cases. I disconnected and rearranged the suction and discharge tubing so that a gallon glass jug or other container could be put in the line between intake and pump. It takes but a few seconds to form so good a vacuum in the jug that the alcohol rushes in in torrents.



Hook up for drawing alcohol from drum into bottle

In a hospital, minutes and even seconds are valuable. There is no time to guess or experiment. When fuses blow particularly cartridge fuses, after locating trouble I take out the whole set and insert new ones. At my leisure, I test those removed and either discard or refill as the case may be. My tester I made out of a doorbell transformer and lamps from Christmas tree lighting circuits. I find lamps more practical than a buzzer since they are noiseless.

It is often difficult to spring a pipe line apart to remove a union, nipple or coupling or to put in a new piece of pipe. I have found a jack, made out of the right length of 2 by 4, or even lighter material, notched on one end and fitted with an ordinary automobile jack at the other to be of great help. With the notch fitted over the nearest elbow or pipe, at right angles to the line under repair, and the jack bearing against another right angle pipe, unions, etc., can be separated and held apart with the greatest ease.

Peterboro, N. H. ARTHUR H. PARKER.

Meter Speeds Up on Low Voltage

CAN ANYBODY advise us what effect a low voltage on the line would have toward speeding up the meter reading? The exact situation we have in mind is where the current into the transformer is supposed to be at 2300 v. and feeds out to the machines at 220 to 230 v. When the voltage on the inbound line drops as low as 1900 v., does this increase the meter reading or the kilowatt hours?

Greensboro, N. C. A. L. F.

Worn Check Valve Gives Trouble

IN THE JULY issue, Bunyan Kennedy on page 439 tells of a check valve that was slightly out of line and it bothered him by letting the feed back up. This check valve, I presume, was of small caliber but the same species of very large caliber can likewise cut up didoes.

We had a pair of low head jet condensers, each serving a 3000-kw. turbine and the machines were loaded to their full capacity. The injection water was approximately 75 deg. F. and the pumps were passing one g.p.m. for each kilowatt or 3000 g.p.m.

We had other units of the reciprocating type that could, in an emergency, take the place of one turbine unit and they were kept in perfect shape but, up to the time of which I am writing, no emergency had ever arisen.

Then it happened! The day shift had taken over the station, the second 3000 had been put on the board and everything was set for another day. The condenser operator always noted the speed of the pump and the index reading on the injection valve; both were adjusted for maximum load.

But he could not get the injection valve open to the proper index mark; the water built up in the glass gage.

That station crew was trained. The condenser operator did not hope and pray that things would right themselves. He notified his superior, the watch engineer, that things were out of whack.

The watch engineer did not ask him (the condenser man) if he had done this and tried that; *he got another unit on the line.*

When the load came on, a very few minutes after the stand-by was in operation, the chief came in. He noted the situation and asked for a full report.

"Only one answer," he said. "Pump up to speed and water goes up in the glass. What's the answer?"

Men who had been operating several years in the station could only look askance. The condenser man wondered what he could have done to gum up the works. No one answered the chief.

Perhaps you have guessed it. The check valve. But in this case it didn't leak! It got stuck so it couldn't properly open. It was 12 in. in diameter and the discharge spilled into a common line through which flowed the discharge of several other units.

When the cover was removed from the check, nothing amiss was noted and it (the cover) was replaced and the pump functioned perfectly, handling full capacity for several days.

This same thing occurred at least four times before the correct solution was reached. The clearance between clapper and valve body was so scant (see drawing) that at a certain opening, possibly 2 in., the clapper was

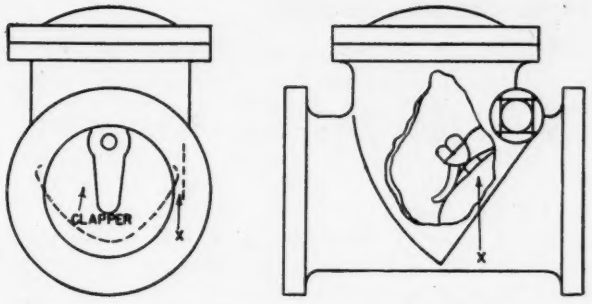


Fig. 2. Worn hole in tongue sometimes caused clapper to swing sideways and lock at X

locked firmly. When the flow stopped and the clapper dropped shut it might open the next time perfectly.

We bored the cast-iron tongue to take a heavy brass pipe for a bushing and made a new brass pin that was a "fit". Then we gave the other twin unit the same treatment and stocked a new clapper and re-vamped tongue.

The new clapper and tongue never were called upon to "spell" the ones in the valves. About everything else on the condensing apparatus was, in time, renewed but the brass bushing.

It is well to remember that the modern centrifugal pump does not push open check valves like the old piston or plunger type. In the latter case something was liable to "bust".

N. Y. City. C. W. PETERS.

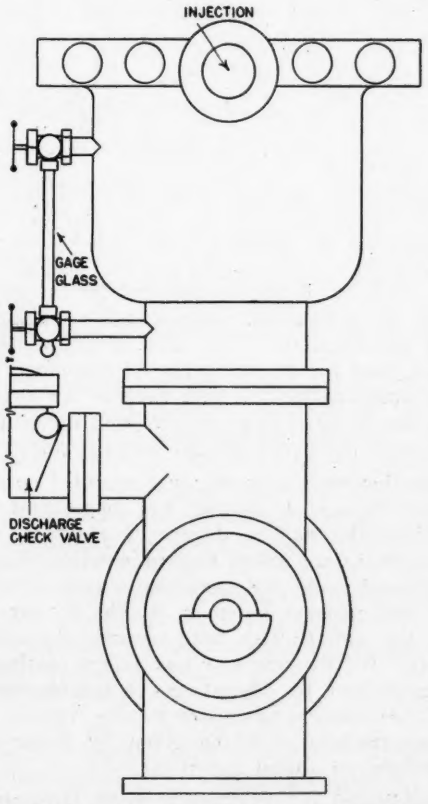


Fig. 1. Location of check valve on condenser

One-eighth Inch

EVERYBODY has heard the saying, "It's the little things that count". Well, that goes for engineering too.

Recently, while analyzing brush cost figures for the d.c. machines operating in our plants it was noted that we were getting 1½ by 1½ by 2⅛ in. brushes but paying for 2¼ in. lengths which was the standard. Further analysis showed that the length dimension was limited by the pressure finger. With the additional ⅛ in. in length the brush pressure contact finger or spring rested on the edge of the brush instead of the brush pressure clip. Upon investigation in the field it was noted that a ¼ in. bevel on the top of the brush was just enough to make the contact finger clear the brush edge and rest properly on the pressure clip. The brush manufacturer, upon query, advised that this bevel would not increase the cost of the brush since it could be done in the same operation when the bevel at the bottom, commutator face, of the brush was machined.

Since we have approximately 7000 brushes of this size operating on our system this additional ⅛ in. in length resulted in 1 month or 650 more running hours per brush or over 4,000,000 more brush running hours on the basis of the number of this size used. In number of brushes this ⅛ in. actually represented 400. And at no increase in cost.

It's these little savings that count and put a plant from the red back into the black and help pay for the increased labor costs.

Tenafly, N. J. KERMIT B. HOFFMAN.

Motor Starter Location

SAFETY and convenience are the prime requisites of any system on motor starting. Very often in looking over an existing layout of motor and starter it is easy to see where the installation can be bettered from the standpoint of either one or both of these considerations. Naturally a safe and convenient layout is the goal always, but due to circumstances and lack of vision or planning the result is not always desirable. Sometimes the lack of these requisites is never missed until an accident occurs. As a rule the most convenient place (for operation) is the safest; the most convenient place (from the installation standpoint) may or may not be the best location as regards safety.

The sequence in the motor branch circuit as required by the Code is shown in Fig. 1. Item 1 and 2 are often combined as a fused safety switch. In many cases, however, the distance between the main line and the motor may be considerable; the actual point of contact with the main line may even be in another room or building or perhaps out on a pole. The disconnect switch is then necessary and must be installed within sight of the motor. In some of the newer installations the motor is located at a point some distance from the starting box. The starting apparatus for all the motors in various parts of the plant are concentrated in a special centralized switch room, and are operated by push buttons located at convenient places. It is necessary to have a means of locking the disconnect switch in the open position when it is necessary to work on the motor. While it is not specified some plants insist on another disconnect switch at the motor for greater safety, which in the diagram would come between 3 and 4.

Naturally the push button magnetic type of control lends itself easily to both convenience and safety. The button does not take up much room and can be located where it can be easily reached by the operator. Even with the hand operated compensator starter a push button for stopping only can be connected in the no-voltage release coil circuit so that in case of accident or necessity the motor may be stopped without going to the compensator. In many cases the starting apparatus may be located on the machine itself where individual motor drive is used.

Perhaps the best way to illustrate how the location of the starting apparatus can be changed for improvement in safety and convenience is to take an example. Figure 2 A shows an arrangement which is by no means safe or very convenient. The circuit supplying the motor is taken direct from an overhead line outside the motor house and is protected by the cutout type of fuses where the fuse is entirely removed from the circuit when the enclosing box is opened. It is necessary to climb the pole when a fuse needs replacing. Glancing again at "A" it will be noticed that the operator has to crowd in between the starter and the motor in order to get to the starting handle located on the right hand side of the compensator starter. The oil switch is located as shown, but is high enough above the floor so that the apparent interference is actually less than shown. The position of the operator is shown at "X." In most cases it is a convenience if the operator can watch the motor when it is starting. The only way in which he could do this on an installation such as is illustrated is to stand with his back to the wall and operate the lever in a sort of back hand manner. If anything happened to go wrong with the motor or the starting box the operator would be in a rather poor position. The motor house is amply large and there is no real necessity of having the switch and compensator in the position shown, at "A." In "B" the starter is shown located on the left hand wall. This is certainly a much better position as regards both safety and convenience. There is still the difficulty of seeing the motor and belt when it is started as the natural position of the operator would be with his back to it. It is more convenient for the mounting to have the switch and compensator up against the wall of the building. "C," Fig. 2, shows the best practical place for mounting the oil disconnect switch and the compensator. A pipe rack or an angle iron support can be fitted up to support both the switch and compensator, the switch being above the starter.

In another case the motor was mounted on a stand and the disconnect switch and compensator was mounted on the wall as shown. A platform was located about a foot above the surrounding floor level and extended under the compensator and switch. The general arrangement is shown in Fig. 3. By simply moving the compensator back towards the switch as shown in "B" the operator has a firm footing, is at the correct level for operating the compensator, and can still see whether the motor starts correctly. Many other illustrations could be given by going in and making notes in almost any plant.

Sayreville, N. J. K. B. HUMPHREY.

Fig 1

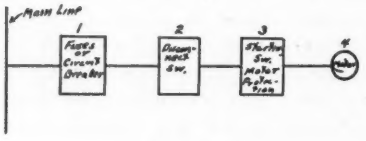


Fig 2

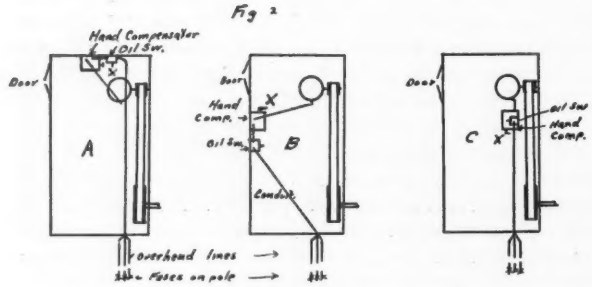
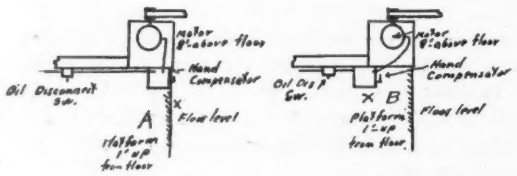


Fig 3.



Figs. 1-3. Good and bad motor and starter arrangements

Chicago Power Show Directory

Power Equipment to be Exemplified in Chicago, Oct. 4 to 9, at the International Amphitheater

AT THE CHICAGO Exposition of Power and Mechanical Engineering, to be held at the International Amphitheater Oct. 4 to 9, exhibits by midwestern manufacturers will be effectively presented, along with displays from leading industrial firms, from all over the United States.

Interesting features will include demonstrations of refractories and insulation for temperature range from refrigeration to steel furnaces, including a sectionally-supported boiler furnace wall which uses no metal, and asphalt roof blocks which are insulating and water resisting. For boiler scale and corrosion control, automatic equipment with fluid-piston operation for positive accurate proportioning of the reagents, also chemicals, glucoside derivatives and special water treatments will be displayed.

Removal of liquids from pipe systems under pressures from 1 to 1500 lb. by traps with capacities of 500 to 240,000 lb. an hour will be of interest, especially as details of stainless steel wearing parts and glass-enclosed operating models will show exactly how the traps operate to discharge condensate, air and sludge.

In the matter of transmission equipment, besides improvements in bearings, gears, couplings, drives and speed controls, new types of belting of high tensile strength, great pliability and long life, adapted for use on modern high-speed drives with small pulleys set on short centers will be displayed. Special couplings will illustrate methods of relieving shock in starting and of taking care of either angular or parallel misalinement. Rubber-housed, ball-bearing pillow blocks will be shown for use where silent operation is essential as in heating, ventilating and air conditioning systems.

Modern methods of lubrication by mechanical oil-pumping units and pressure greasing systems, as well as equipment for hand-controlled lubrication will be on display. Also full exposition of the manufacture and blending of lubricants, with exposition of the care taken by lubricant manufacturers to ensure that lubricants are properly adapted to the service for which they are used.

Control of pressure, temperature, voltage and current will be demonstrated, including regulators, relays, mercury switches, voltage regulators, rheostats and remote-control of motor-operated devices.

Heating, cooling and ventilating equipment and their application in air conditioning will be shown, with piping system construction and pipe fittings, valves, pipe cutting and threading machines.

Generating plant equipment will include stokers, boiler feeders, steam and oil separators, condenser construction, coal and ash handling systems, Diesel engines, air compressors, filtration and strainer systems.

Exhibits will be open from noon to 10:30 p. m. daily from Oct. 4 to Oct. 8 and on Oct 9 from noon to 6 p. m. No admission fee will be charged, but admission will be by registration at the entrance to the International Amphitheater. Invitations will be extended by the management and by exhibitors to users of power, executives, operating and maintenance men in service plants, industries and utilities.

In the machine tool field, operations shown will include lathes, shapers, planers, grinders, sanders, drills, rotary files, screw machines, buffers and other metal working and finishing equipment. Flexible shafts for ⅛ to 2 hp., for driving portable tools will be exhibited, and their use in industrial operations emphasized.

Evening Illustrated Lecture on Applied Research

The evening of Oct. 7 a combined meeting of the A.S.M.E., A.I.E.E., Western Society of Engineers and Chicago Chemists' Club will be held at which Dr. Thomas of Westinghouse Co. will speak on Adventures in Electricity, with illustrative experiments.

The show will offer an unique opportunity for industrial engineers and executives to investigate and compare the latest mechanical and power equipment and select that which is best suited to improve the economy of their plants. Also it will serve as a national review of current progress in the fields of power and mechanical engineering for all who wish to keep informed up to the minute.

Chicago Power Show Directory

Herewith is given a list of exhibitors, the booths in which their exhibits will be found and a brief resume of important exhibits:

Ahlberg Bearing Co., Chicago, Ill.....431-433

Allen-Bradley Co., Milwaukee, Wis. 515-517

American Air Filter Co., Louisville, Ky.....6-7

American Brass Co., Waterbury, Conn.....3

American Metal Hose Branch, Waterbury, Conn. 4

American Monorail Co., Cleveland, Ohio.....57-58

American Pulverizer Co., St. Louis, Mo.....50
This exhibit in connection with that of the D. H. Skeen Co., will demonstrate an operating model of the American Rolling Ring Coal Crusher.

Armstrong-Bray & Co., Chicago, Ill.....105

Armstrong Bros. Tool Co., Chicago, Ill.....105
Armstrong Machine Works, Three Rivers, Mich.129-131

Special interest will be given by a glass model of the Armstrong Inverted Bucket steam trap, operating at 5 lb. steam pressure and showing how the trap handles air and dirt, in addition to the normal function of removing condensate without any loss of live steam.

E. B. Badger & Sons Co., Boston, Mass.....442
Barrett-Christie Co., Chicago, Ill.....130-132
Barrett-Cravens Co., Chicago, Ill.....113-115
Beaver Pipe Tools, Inc., Warren, Ohio.....524

Main attraction will be Model-A portable pipe and bolt machine with rack and pinion feed, quick-opening dieheads with standard range ⅛ to 2 in. but capable of threading pipe up to 12 in., choice of wheel-and-roller or knife cutoff, demonstrated in action. Beaver cutters, dies, vises and reamers will also be displayed in ratchet and geared types. W. S. Andrews, Chicago District Manager, will be in charge.

Becker Bros. Carbon Co., Chicago, Ill.....335
Bird-Archer Co., Chicago, Ill.....220
Boston Gear Works, Inc., No. Quincy, Mass...52-53
Brett Machinery Co., Chicago, Ill.....505
Breuer Electric Co., Chicago, Ill.....119
Bridgeport Brass Co., Bridgeport, Conn.....422-424
Carrier Corp., Newark, N. J.....240
Caterpillar Tractor Co., Peoria, Ill.....209-211
Chicago Metal Hose Co., Maywood, Ill.....516
Chicago Rawhide Mfg. Co., Chicago, Ill. 311
Clements Mfg. Co., Chicago, Ill.....242
Cleveland Worm & Gear Co., Cleveland, Ohio..404
Clipper Belt Lacer Co., Grand Rapids, Mich...227
Coe Mfg. Co., Painesville, Ohio.....507
Coffing Hoist Co., Danville, Ill.....317
Columbia Vari-Speed Co., Wheaton, Ill.....218
Connery Construction Co., Philadelphia, Pa...328

Small model of a power unit will be interconnected by various forced draft ducts; induced draft preheater ducts will feature Connery's Improved Expansion Stiffened construction; full size sections of the expansion ribs, guide vanes and bearings used in conjunction with this character of work will be displayed.

Continental Machine Specialties, Inc., Minneapolis, Minn. 446
Crane Co., Chicago, Ill. 1-2
Cutler-Hammer, Inc., Milwaukee, Wis.....427-429
Dayton-Rogers Mfg. Co., Minneapolis, Minn...139
Dayton Rubber Mfg. Co., Dayton, Ohio.....428-430
Detroit Power Screwdriver Co., Detroit, Mich...505
Jos. Dixon Crucible Co., Jersey City, N. J....421
Economy Tool & Machine Co., Muskegon Heights, Mich. 505
Edward Valve & Mfg. Co., E. Chicago, Ind.....51

Against a background of photo murals will be exhibited high-pressure alloy steel non-return valves with Edward internal parts and Impactor handwheels; also complete line of blow-off valves featuring EValloy seats, disks, and steams, including valves suitable for welding into piping; combination feedline stop and check valves in one body and forged steel globe and angle stop valves for all pressure ratings; check valves with vertical lift piston, atmospheric relief and bleeder line stop-check valves, all steel relief valves, cross-sectioned to show working parts. Representatives in attendance will be W. W. Crawford, President; J. E. McDonald, Sales Manager; W. F. Crawford, Sales Promotion Manager; W. W. Mohr, Chief Engineer.

Ehret Magnesia Co., Valley Forge, Pa.....434
Elgin Softener Corp., Elgin, Ill.....509

Exhibit will include a model boiler, electrically operated with glass peep holes to show the circulation within the boiler, equipped with an Elgin System of boiler water conditioning which will include a treating system and a sludge deconcentrator of glass to show the benefits from the correct control of boiler water concentration. Also improved developments in zeolite water softening equipment, water testing equipment and other new improvements in the field of water conditioning.

Engineering Sales Co., Chicago, Ill.....442
Fafnir Bearing Co., New Britain, Conn.....319-321
Faville-Levally Co., Chicago, Ill.....212
Foley Mfg. Co., Minneapolis, Minn.....527
Forty-Eight Insulations, Inc., Aurora, Ill.....339
Garlock Packing Co., Palmyra, N. Y. 223

This exhibit will consist of a general line of mechanical packing for use in power installations, also will feature Garlock Klosures, a high-quality grease and oil seal for revolving shafts. The mechanical packings will include metallic, flax, asbestos, duck and rubber.

General Electric Vapor Lamp Co., Hoboken, N. J. 134

Feature will be the latest Cooper Hewitt lamps for industrial lighting. The salient features of this new lamp are improved appearance, horizontal hanging, lower power consumption, increased efficiency and instantaneous starting. The exhibit will also include Kon-nec-tors, heavy duty Mercury Switches, and Neon Glow Lamps, the low wattage, pilot and indicator lamps.

Graham Transmissions, Milwaukee, Wis.....521-523
A. P. Green Firebrick Co., Mexico, Mo.....409
Grinnell Co., Inc., Providence, R. I.....305

Prefabricated piping will be featured, also allied products such as welding fittings and special power hangers including the Grinnell Genspring Hanger.

Grob Bros., Grafton, Wis. 503
D. W. Haering Co., Inc., Chicago, Ill.....118
Hamilton Mfg. Co., Two Rivers, Wis. 417-419
Hammett Electric Arc Welder Co., Kansas City, Mo. 309
Hayes Institute of Combustion, Chicago, Ill...336

Heating, Piping & Air Conditioning, Chicago, Ill. 327

Independent Air Filter Co., Chicago, Ill.....538

Industrial Power, St. Joseph, Mich. 423

Jackson Electrode Holder Co., Detroit, Mich....309

Janette Mfg. Co., Chicago, Ill.....432

Jenkins Bros., New York, N. Y.....204-208

Representatives present will be: H. J. Barnsley, engineer; Harry Taif, George Davidsen and George Royal, salesmen; R. B. Osgood, branch manager. Here will be found a complete line of Jenkins bronze, iron and steel valves displayed against a modern background, electrically illuminated, so that the name, trade mark and products of Jenkins Bros. will stand out in a pleasing manner. Illustrations which show typical installations will be included as an integral part of the unit.

Johns-Manville, New York, N. Y.....232-234

Wide variety of products, which serve the power industry in a number of ways, will be featured, including a line of insulating and insulating-refractory materials designed to meet every temperature condition encountered in the power plant. Under the title, Barriers to Industrial Waste will be displayed JM-20 and Silocel Insulating Bricks together with Superex, Asbestos-Sponge Felted, 85% Magnesia and Rock Cork sheet block and pipe insulations. Refractory cements will include Firecrete, for moulding special shapes and small monolithic linings; Hellite, for bonding and wash-coating firebrick and refractory cements for various types of industrial equipment. Complete line of packings and gaskets for any service. For electrical service, Transite Conduit, of asbestos-cement composition, said to be incombustible, mechanically strong, corrosive resistant and unaffected by electrolysis; Transite Korduct a thin-walled conduit for enclosure in concrete; and Asbestos Ebony Sheets for switchboards and panels.

Johnson Bronze Co., New Castle, Pa.....140

Johnson Corp., Three Rivers, Mich.....132

Johnson Welding Equipment Co., Chicago, Ill...309

Johnston & Jennings Co., Cleveland, Ohio....50

Jones & Laughlin Steel Corp., Pittsburgh, Pa..314-316

Keasbey & Mattison Co., Ambler, Pa.....322-324

This exhibit is designed to feature as attractively and forcefully as possible the company's various Asbestos and Magnesia products and to show their installation in outstanding projects. Low and high pressure insulations, in pipe, sheet, block, blanket and cement forms will be featured as well as packings.

Keeney Pubg. Co., Chicago, Ill.....327

Keuffel & Esser Co., Hoboken, N. J. 318-320

Fred C. Kramer Co., Chicago, Ill.....507

Kron Co., Bridgeport, Conn. 543

Link-Belt Co., Chicago, Ill. 304

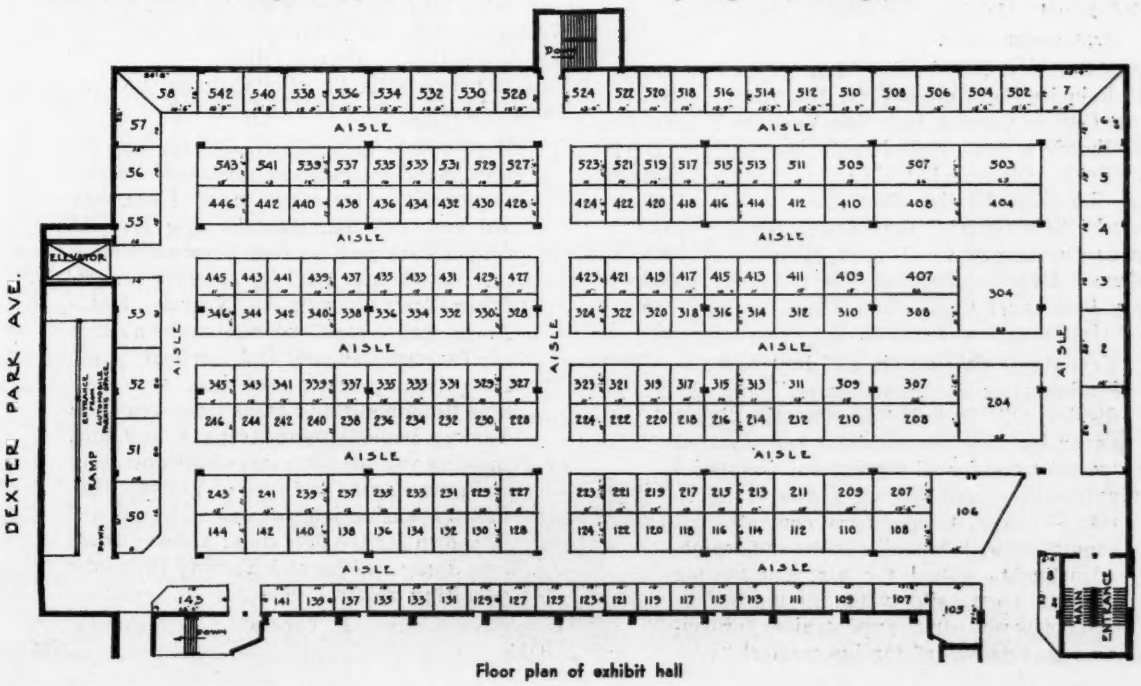
With back wall brilliantly illuminated and dioramas of a stoker installation and of a conveyor in the end sections, will be shown a display of chain drives, small power transmission items, bearings and take-ups, a silent chain drive and two belt conveyor idlers. A Link-Belt motorized reducer and a motorized variable speed transmission and worm gear reducer unit will be operating and a Link-Belt stoker will be on exhibit.

Louden Machine Co., Fairfield, Ia.....210

Lovejoy Flexible Coupling Co., Chicago, Ill...133

Mayer & Oswald, Inc., Chicago, Ill.....339

Mercury Mfg. Co., Chicago, Ill.....510



Floor plan of exhibit hall

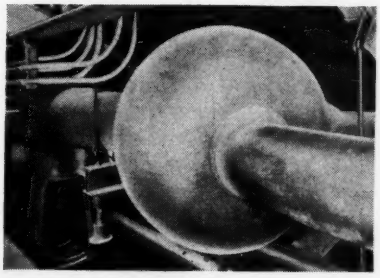
Meriam Co., The, Cleveland, Ohio.....339
Mill & Factory, New York, N. Y.....111
Modine Mfg. Co., Racine, Wis.....222-224
Moore Special Tool Co., Bridgeport, Conn.....505
Morse Chain Co., Ithaca, N. Y.....110-112
Regular line of products will be shown, including silent and roller chain drives, chain and Morflex flexible couplings, Pullmore clutches and Kelpo clutches.
Motor Improvements, Inc., Newark, N. J.....312
Nathan Mfg. Co., New York, N. Y.....243
National Aluminate Co., Chicago, Ill.....329
Facilities of the laboratory for analysis of feedwater will be presented and the methods of the Nalco system of feedwater conditioning demonstrated and details emphasized. A. E. Warner, director, will be in charge of the exhibit.
National Cylinder Gas Co., Chicago, Ill.....309
New Departure Div.-General Motors Corp., Bristol, Conn. 405
Norma-Hoffman Bearings Co., Stamford, Conn..120-122
Nutting Truck Co., Faribault, Minn. 443
Oilgear Co., Milwaukee, Wis. 536
Oster Mfg. Co., Cleveland, Ohio.....436
Parker Appliance Co., Cleveland, Ohio.....413-415
Plibrico Jointless Firebrick Co., Chicago, Ill...207
Power, New York, N. Y.....108
Power Plant Engineering, Chicago, Ill.....323
Prat-Daniel Co., Port Chester, N. Y.....442
Ramtite Co., Chicago, Ill. 528
Reading-Pratt & Cady Div., American Chain & Cable Co., Bridgeport, Conn. 539-541
Here will be displayed a representative line of bronze, iron, steel and bar stock valves, also an 8 in. cast steel, welded-end, motor-operated gate valve in operation during the show. Attendants will be John C. Harrington and G. F. Helfrich from the Chicago office; J. P. Ferguson, Assistant General Manager of Sales, from the Bridgeport office.
Reeves Pulley Co., Columbus, Ind.....412
G. P. Reintjes Co., Kansas City, Mo.....50
Revere Copper & Brass, Inc., New York, N. Y...512-514
J. E. Rhoads & Sons, Philadelphia, Pa.....114-116
Ric-Wil Co., Cleveland, Ohio 530-532
Ridge Rool Co., Elyria, Ohio.....420
Rivett Lathe & Grinder, Inc., Boston, Mass.....310
Robbins Engineering Co., Detroit, Mich.....505
Rockwood Mfg. Co., Indianapolis, Ind. 533
Safety Belt Lacer Co., Toledo, Ohio.....345
Sarco Co., Inc., New York, N. Y.....124
Keynote of the exhibit will be "Sarco is headquarters for steam traps," and the display will include thermostatic, liquid expansion, float-thermostatic and inverted bucket traps for all heating and industrial applications and for all pressures up to 500 lb. Also temperature controls and regulators with sensitive bulbs and remote adjustment control for air conditioning systems, steam and water mixing valves and a new scraper-cleaned strainer for continuous removal of foreign matter.
Chas. A. Schieren Co., New York, N. Y.....143
F. E. Schundler & Co., Inc., Joliet, Ill.....313-315
D. H. Skeen & Co., Chicago, Ill.....50
S.K.F. Industries, Philadelphia, Pa.....228-230
Smith Welding Equipment Co., Minneapolis, Minn. 309
Snap-on Tools, Inc., Kenosha, Wis.....229
South Bend Lathe Works, So. Bend, Ind.....435
Southern Power Journal, Atlanta, Ga.....216
Staynew Filter Corp., Rochester, N. Y. 219-221
Steel & Tubes, Inc., Cleveland, Ohio.....123-125
Stock Engineering Co., Cleveland, Ohio.....212
N. A. Strand & Co., Chicago, Ill.....142
Sullivan Machinery Co., Michigan City, Ind...213
W. O. & M. W. Talcott, Inc., Providence, R. I...542
Timken Roller Bearing Co., Canton, Ohio....502-504
Titeflex Metal Hose Co., Newark, N. J.....127
Trabon Engineering Corp., Cleveland, Ohio...117
Toledo Pipe Threading Machine Co., Toledo, Ohio 511
H. O. Trerice Co., Detroit, Mich.....141
Veeder-Root, Inc., Hartford, Conn. 144
Walworth Co., So. Boston, Mass. 518-520
Ward-Leonard Electric Co., Mt. Vernon, N. Y..244
Wells Manufacturing Corp., Three Rivers, Mich. 346-445
Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa. 532-534
Westinghouse exhibit will show a demonstration of its new breath relay by means of which electric lights may be extinguished or lighted; also will be included splash-proof, drip-proof motor with water flowing over it, model of a Type M turbine, and sectionalized type CSP transformer.
Weston Electrical Instrument Corp., Newark, N. J. 246
C. H. Wheeler Mfg. Co., Philadelphia, Pa.....212
L. J. Wing Mfg. Co., New York, N. Y.....339
Wolverine Tube Co., Detroit, Mich.....414
Wright-Austin Co., Detroit, Mich. 8
Yale & Towne Mfg. Co., Philadelphia, Pa.....55
Yarnall-Waring Co., Philadelphia, Pa.....5
Here will be an extensive display of Yarway Tandem Seatless Blow-off Valves, sectioned, for pressure ranges of 400, 600, 900 and 1500 lb., also the new type of forged steel unit Tandem Blow-off Valves for the 600 and 1500 lb. pressure ranges. Other features will be Yarway Hi-Lo Alarm forged steel water columns; a series of Yarway inclined and vertical gages for various prssure conditions, with new type illuminator and other improvements; Yarway impulse steam traps, a new line, showing various diagrams of the operation and advantages; new type of Yarway Gun-Pakt expansion joint of wrought steel will be shown for the first time; Yarway Involute Spray nozzles and Yarway hydraulic operating valves.
Youngstown Sheet & Tube Co., Youngstown, Ohio 506-508

New Equipment

Spherical Steam Header

ONE OF THE MOST noteworthy developments in the direction of lighter, but stronger, steam plant equipment is to be found in a large steam header which was recently installed in Waterside Station of the Consolidated Edison Co. where it is receiving steam from two 500,000 lb. per hour boilers, at 925 deg. F. maximum temperature and 1250 lb. p.s.i. pressure to a 50,000-kw. steam turbine.

This revolutionary type steam header was designed by the Engineering Department of The M. W. Kellogg Co. Built in the form of a perfect sphere, of carbon ½ per cent Molybdenum forged steel 2 3/16 in. thick, the header, which is 48 in.



o.d., receives steam from the boilers through two 12-in. heads and delivers it to the turbine throttle valve through one 20-in. connection. In its fabrication two perfect hemispheres were first built and then were masterwelded together in accordance with the terms of the A. S. M. E. Code for Unfired Pressure Vessels.

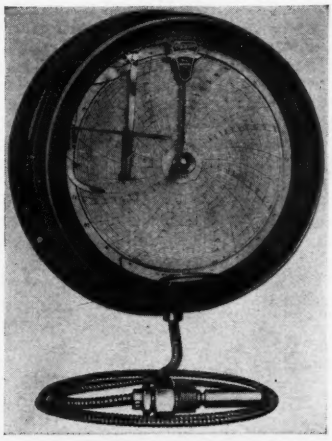
It is claimed that this design of spherical steam header effects an appreciable saving in both weight and space over steam headers of the regular design, that it operates with uniform high efficiency and furnishes steam of a uniform temperature to the turbine.

Mono-thurm Thermometers

A MODERNIZED LINE of indicating and recording thermometers, incorporating improvements in design, construction and operating characteristics is being introduced by The Foxboro Company, Foxboro, Mass. Known as Mono-therm thermometers, these instruments employ an improved thermal system which provides a complete permanent seal for the actuating medium. The entire system is either welded or braised in such a way that it becomes an integral piece of metal. This new construction it is claimed reduces to a minimum any possibility of leaky joints which would affect the accuracy of these instruments. Even in face of mechanical shocks, continued vibration, and overrange temperatures, a tight thermal system is assured. The Mono-therm construction is at present being applied to Foxboro thermometers of the vapor-pressure, gas-filled and liquid-filled types.

All of the Mono-therm recording thermometers are so designed that the charts may be changed easily with one hand, a feature which saves time and effort.

Available with the Mono-therm recording thermometers is a new extra overrange protection. The liquid-filled instrument can be protected against an overrange up to a maximum of 500 deg. F.; the gas-filled against an overrange of 100 per cent up



to a maximum of 1000 deg. F. and the vapor-pressure type for a 100 per cent overrange to the break-down point of the actuating medium.

Voltage Restraint Relay

GENERAL ELECTRIC'S new polyphase power directional relay, Type CBP, has two "cup-type" torque-producing elements on one shaft. One element is a polyphase power directional element; the other is a voltage restraint element, giving a directional relay which normally stays in the open position.

When a fault occurs, the voltage restraint collapses, allowing the directional element full control.

In addition to its use as a crude polyphase impedance relay, the CBP gives very satisfactory "directional control" and can be used even with instantaneous as well as delay overcurrent relays because it cannot close its tripping contacts on load current. Only the control voltage is on the contacts so there is no chance of not making contact on account of low voltage or difficulty in short-circuiting overcurrent relay coils of low impedance.

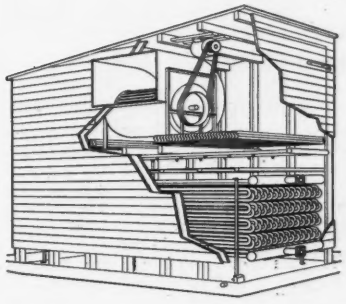
Insulation-Resistance Test Set

USING a guarded circuit, this new insulation resistance test set made by the Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia, Pa., is entirely free from the effects of leakage currents. The instrument conforms with the ASTM "Standard Methods of Test for D-C Resistance of Insulating Materials"—No. D-257-37T.

Switches are designed to simplify operation and eliminate calculation. Calibration of the galvanometer deflections is facilitated by the specially designed Ayrton shunt. Simply turning the shunt to the calibrating portion automatically connects the circuit for calibration. Results are obtained by merely dividing the calibration reading by the test reading.

Evaporative Condensers

FRICK CO., Waynesboro, Pa., is offering a new line of evaporative condensers for ammonia and Freon refrigerating systems. These condensers combine in one unit the advantages of a forced draft cooling tower and highly efficient surface condenser. The cooling water is sprayed



over coils, the water is collected at the bottom in a tank and kept in circulation by a small motor-driven pump. Motor-driven fans above the nozzles draw cold air upward through the casing of the unit in counter-current fashion. Double sets of eliminator plates prevent moisture entrained with the air from being blown away by the fans and a float valve installed in the pan supplies make-up water to replace that evaporated in cooling the the condenser. Capacities vary from 5 to 175 t. of refrigeration, and the six sizes range from 3000 to 15,000 c.f.m. fan capacity.

Compact Pump Unit

A TWO-STAGE built-together pump has been developed by Fairbanks, Morse & Co. 900 S. Wabash Ave., Chicago, Ill., designed to operate against heads up to 500 ft.—higher than could be handled by a single-stage unit. In many applications it offers a less expensive alternative for multi-stage and split-case pumps, and its compactness and sturdiness qualify it for portable and semi-portable as well as stationary service.

The new F-M pump is well adapted for all classes of general pumping service with liquids low in viscosity and free from excessive foreign matter. Because of its compact design, the pump is especially advantageous where space is limited. No special foundation is required; the pump is complete in itself and can be mounted in any convenient horizontal, vertical or angular position.

This new built-together pump consists essentially of a two-stage centrifugal pump, with enclosed bronze impellers, mounted

directly on the shaft of an F-M splash-proof motor. There are no flexible coupling or alignment problems with which to contend. Impellers for the two stages are placed back to back, compensating thrust. Improved hydraulic design is attained by placing the first stage unit next to the motor and the second stage

on the outside, simplifying the cross-over passage and placing the stuffing box under suction instead of pressure. A mounting leg under the pump end gives the unit added stability.

Burst-Proof Steam Hose for Industry

THE B. F. GOODRICH CO., Akron, Ohio, has recently introduced an industrial safeguard known as a Burst-Proof steam hose. When this hose fails it will leak but nothing can cause it to burst except an external blow severe enough to cut the wire reinforcement. It is recommended for 200 lb. working pressure in all sizes, with a safety factor of 15 to 1 in larger diameters and up to 35 to 1 in small diameters. The sizes available range from ⅜ to 2½ in.

Tube (A) and insulating layers (C, E) of Burst-Proof steam hose are made of a special heat-resisting rubber compound similar to those used for automobile tires and cover stock of hot material conveyor belt. This rubber retains its liveliness and sealing properties to a remarkable degree even when subjected to high pressure steam.

Burst-Proof hose is designed with a reinforcement of high tensile steel wire (B, D) which, unlike cotton fabric construction, cannot burn out and deteriorate. Wire is applied in a braided form with openings large enough to permit the rubber to rivet itself, thus preventing any possibility of tube collapse. It will be noted

that the form of wire tape used consists of seven or eight strands of wire laid side by side. This construction utilizes the maximum strength of the wire so that no additional reinforcement is needed beyond a single ply of wire tape in small sizes and two plies in larger sizes.

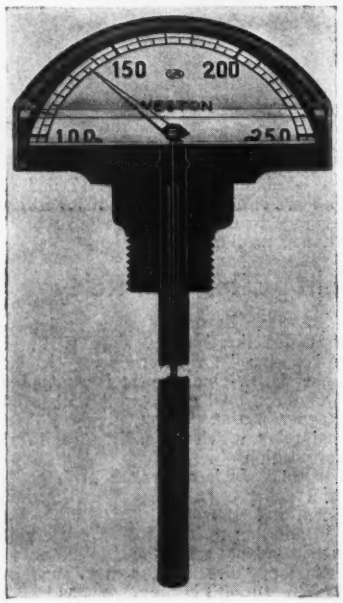
Outside of the wire braid and underneath the cover is embedded an additional braid of strong asbestos cord (F). Being a slow conductor of heat, this asbestos layer protects the cover from burning.

Completing the construction is a heavy, long-wearing black rubber cover which is heavily compounded with a special Goodrich anti-oxidant, known as Agerite, to give it unusual age-resisting qualities.

New Temperature Gages

THE INITIAL UNITS in a line of modern temperature gages which differ materially from any previous type of industrial indicating thermometer have just been introduced by the Weston Electrical Instrument Corporation, Newark, N. J. These new instruments are of the modern dial-and-pointer type, said to be the first industrial application of a new "coils-within-coils" design for the bi-metal temperature-sensitive element. This all-metal temperature element is sheathed within a stainless steel stem. The circular dial case, 3 in. in diameter, is mounted at right angles to and at the top of the stem. Accuracy is guaranteed to 1 per cent over the entire scale.

Several models are being introduced for use in the power plant field: (1) For water and oil temperatures of Diesel engines, the scale reading from 50 to 300 deg. F. Its stem length is 2½-in. and the installation connection is ½-in. S. P. T. (standard pipe



thread). (2) For exhaust gas temperature of Diesel engines, the scale reading from 200 to 1000 deg. F. The stem length is 6-in. and the connection is ½-in. S. P. T. The standard scale ranges for general use are:

—40 to	120 deg. F.
0 to	200 deg. F.
50 to	300 deg. F.
50 to	400 deg. F.
50 to	500 deg. F.
150 to	750 deg. F.
200 to	1000 deg. F.

Stem lengths from 2½-in. to 12-in. are available, or longer on special order.

The scale divisions of the circular dial are easy to read; the anodized aluminum dial face offers a distinct advantage, since this type of metal scale is unaffected by the temperature to which the head may be subjected.

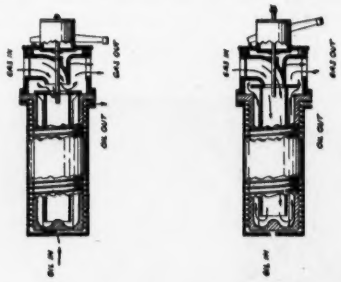
The construction of the temperature element is inherently rugged and durable, with the result that the temperature gage can easily withstand the engine vibrations. Due to its all-metal temperature element, it responds rapidly to temperature change.

Low Temperature Machines

IN CONNECTION with air conditioning installations, where temperatures of 50 to 75 deg. F. below zero must sometimes be maintained, York Ice Machinery Co. has adopted nickel alloy cast irons for cylinder, top head, piston, crankcase and bearing head of its Freon-12 compressors because of machinability, wear resistance and pressure tightness.

Oil Heater

GOULDS PUMPS, INC., Seneca Falls, N. Y., recently developed an oil heater which utilizes exhaust gas from internal combustion engines and intended to elimi-

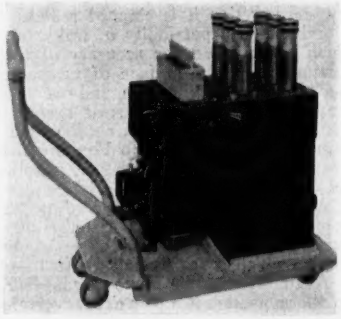


nate the operating expense of the electric heater usually used with centrifuges. The heater is composed of a head through which exhaust gas enters at the center and leaves in an annular ring, a casing, a heat exchanger and a baffle, the latter designed so that it acts as a control valve. Oil enters at the bottom, works its way up along the helical grooving and out at the top. Exhaust gas passes from the head down through the baffle and up between the baffle and exchanger through the annular valve. The baffle is raised or lowered manually or thermostatically to control the valve opening and the amount of gas passing through and effective in heating the oil.

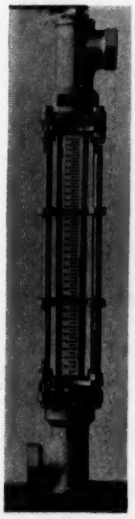
Carbonization is avoided by designing the areas for positive flow over all parts. The heater heats 150 g.p.h. to the required 175 deg. F. The unit may be easily cleaned by dropping the casing and exposing the helical oil grooving and by dropping the exchanger elements so that the gas passages may be wire-brushed. Pipe connections do not have to be disturbed.

Oil Circuit Breaker Unit

FOR USE IN metal-clad switchgear assemblies a compact oil-blast circuit breaker arrangement has been developed by the Delta-Star Electric Co., Chicago, Ill.



The complete control, solenoid operating mechanism, control switches, interlocks and manual operating handle are combined in a self-contained unit. By means of a truck, the entire unit can be placed in or removed from the switchgear enclosures. O.C.B. rating 7.5 kv., 25000 kv-a.



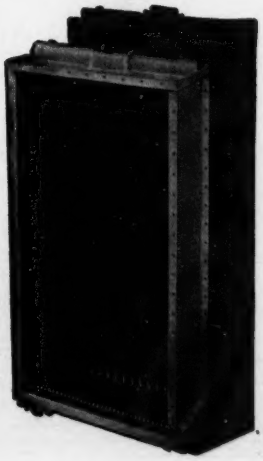
Interchangeable Rotameter Tube

FISCHER & PORTER Co., Philadelphia, Pa., has developed a machine by means of which interchangeable rotameter tubes can be made, which avoids individual adjustment. Permanent colored pigment is fused into the etched graduations, usually in red but can be supplied in any color desired. If a tube is broken, it can be replaced by another without calibration or adjustment. This improvement is expected to reduce cost, as well as widen the field of application of rotameter flow meters.

New Blast Heater

MODINE MANUFACTURING Co., Racine, Wis., announces a new blast heater for heating, ventilating, air conditioning and process applications. Incorporated are a number of new design features which materially increase the structural strength and effectiveness of the heat transfer surface. Patented expansion bends allow each tube to expand and contract independently so as to eliminate expansion strain and possibility of leakage from this cause.

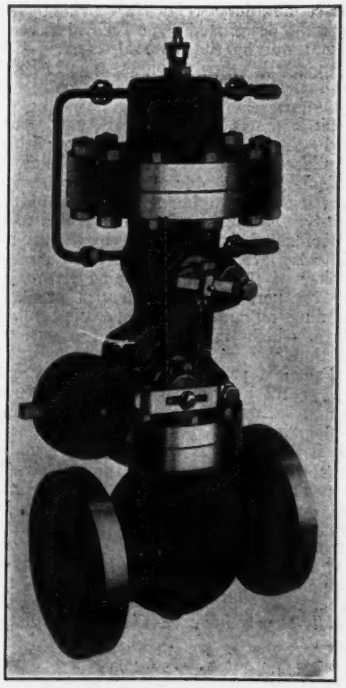
Headers and tubes are cylindrical and seamless and are brazed into a single rugged unit without the use of gaskets, bolts or screw joints. By brazing the headers to the inlet and outlet bosses, bolting headers to casing and bolting casing to inlet and outlet bosses external piping strain is transferred to the steel casing instead of to the copper condenser. Orificing of tubes has been eliminated by the use of a special steam distributing plate which assures even distribution of steam the full width of the condenser. These blast heaters are available in large variety of sizes and capacities, a total of 252 different heaters being available.



Feedwater Regulators

KNOWN as the Copes Flowmatic Regulator, a new two-element steam-flow type of boiler feedwater regulator has been introduced by Northern Equipment Co., Erie, Pa. It meets the demands for more accurate feedwater control on modern high-rating boilers and on other units subjected to rapid, wide load fluctuations. It feeds the boiler according to the rate of steam flow and provides the water level characteristics that give best operating results on the individual unit. A higher water level can be provided on heavy loads than on light, or a practically constant level can be maintained for all ratings.

It has two control elements. The steam flow controller measures the rate of steam flow by taking the pressure drop through the superheater. The water level

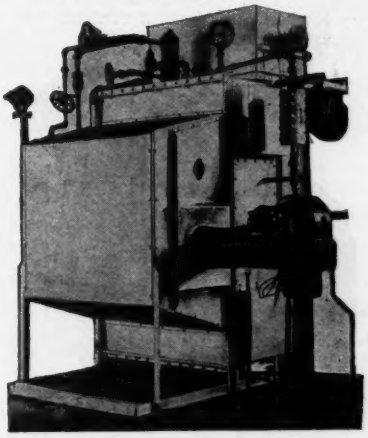


thermostat responds to changes in the boiler water level. These two control elements are connected mechanically to the feedwater control valve in such a way that the valve is positioned by the resultant of the two forces.

The feed control valve may be direct-operated or hydraulically-operated, depending on the service conditions. It may be installed at any position in the boiler feed line. It can be equipped with a motor operator permitting repositioning of the valve by push button from the operating panel. It is furnished in all pressure standards from 250 lb. upward. Valves are furnished in 2- to 6-in. sizes, inclusive.

Small Self-Contained Boiler

SMALL, SELF CONTAINED BOILERS adaptable to automatic operation fill the needs of certain industrial processes and have been developed by Steam Motors, Inc., Newton, Mass., in three sizes for evaporation of 500, 800 and 1200 lb. of water per hr. They may be operated at any pressure from 50 to 1000 lb. per sq. in., with total temperatures up to 850 deg. F. They are fired by oil under automatic regulation using electric ignition.



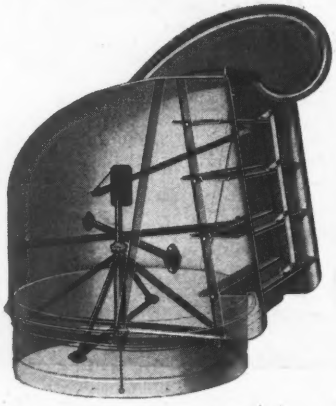
The boilers are of the natural circulation water tube type with two drums, and the furnace is formed by an extension of two rows of tubes. An integral economizer can be supplied if desired. Tests at operating pressures from 275 to 500 lb., ranging from 81.2 to 83 per cent based on a higher heat content of 19,300 B.t.u. per lb. of oil.

Remote Water Level Gage

RELIANCE GAUGE COLUMN Co., Cleveland, O., has recently put on the market a new remote reading water gage, the Eye-Hye, to solve the problem of reading where it is difficult to see the gage. Two models, one for high and one for low pressures, are made. An illuminated gage conveniently located on the instrument board or other handy place is connected to the actual water gage on the water column or boiler drum by means of copper tubing which may be bent around obstructions as desired. The water level in the boiler shows in the Eye-Hye gage as a bright green liquid called Vizzene.

Rotary Roof Ventilator

FOR INDUSTRIAL and commercial building applications the Swartwout Company of Cleveland has recently announced a new rotary roof ventilator. In basic principle it is the same as the original Swartwout Rotary but in detail construction offers many improved features of recent development. Foremost of these is the new stainless steel, fully enclosed, dust-tight, oilless ball bearings on which the head turns with the wind. Interior construction is of streamlined steel tubing welded into a one-piece head frame of great strength and minimum friction resistance.



This rotary is made in sizes from 12 to 72 in. throat diameter and is especially adaptable to general ventilation as well as for removal of smoke, fumes, excessive heat, moisture, and similar substances.

New Constant Level Oiler

TRICO FUSE MFG. CO., Milwaukee, Wis., announces a new line of inexpensive constant level oilers known as the Levomatic for automatically maintaining an accurate level of oil in ring and ball bearings of motors, line shafts, pumps, and other machinery having oil wells. As oil is used up in the bearing chamber, it is automatically replaced with fresh oil from the reservoir.

There are no delicate parts to become out of order. No attention is required after the Levomatic is installed except to fill the reservoir periodically. The crystal clear glass reservoir is screwed to the solid bronze cadmium-plated fitting; therefore, can be removed and conveniently refilled. This feature is especially valuable where installations are in dark or hard-to-get-at places.

Made in four sizes, Levomatic Oilers are primarily designed for low cost applications on small bearings and give a modern, mechanical touch to any machine to which they are applied.

Metal Protection

REVERSAL OF POLARITY of metal surfaces in boilers and condensers by passing of external low-voltage current through insulated electrodes to internal anodes is the basis of the Kirkaldy electrolytic metal protection system, carbonate, sulphate and silica radicals being carried to the anodes instead of to boiler surfaces, which are made cathodic, and slime in condenser cooling water being carried to the anodes instead of to tube surfaces. By the reversal of polarity, a hydrogen film is formed at the boiler surfaces, preventing the adhesion of scale and corrosive action. The low-voltage current is supplied by a motor-generator set and carried through a distributing board to master electrodes, thence to the anodes and through the water to the cathodic boiler surfaces. While the system has been in use since 1924 by large utility installation, new details of installation and insulation have been recently worked out and are now available from the Electrolytic Metal Protection, Inc., 247 Park Ave., New York, N. Y.

Type HEA Auxiliary Relays

A NEW HIGH-SPEED, hand-set, multi-contact auxiliary relay for switchboard mounting, designated Type HEA, has been brought out by the General Electric Co. to supersede the previous type PB-58 multo-contact. The new relay is available in two models, the HEA11A, having 6-circuit contacts, and the HEA11B, having 10-circuit contacts. Operating within 20 milliseconds (1¼ cycles), this relay is particularly applicable where a number of operations are to be performed simultaneously. Among the functions which may be performed simultaneously by the use of this relay are: tripping the main circuit breaker of the circuit, tripping an auxillary breaker, opening a neutral breaker, sounding an alarm, and operating other relays which in turn perform various functions.

Principal parts of the HEA relay are a Type SB-1 switch equipped with three torsion springs which throw the contacts to the "operated" position when the trip coil is released. A small capacitor under the coil reduces arcing of the coil circuit contacts of 125 and 250 v. relays. Contacts are silver-to-silver and will carry 20 amp. continuously or 250 amp. for 3 seconds.

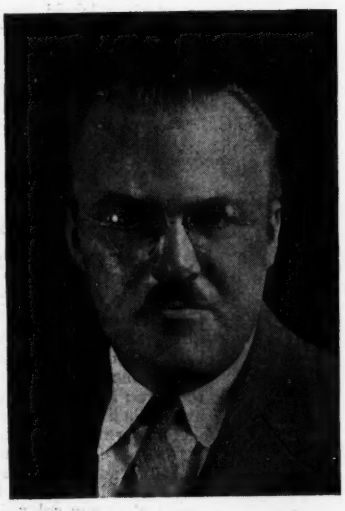
Only the resetting handle and a small escutcheon are visible on the front of the panel. A white arrow on the resetting handle clearly indicates the position of the contacts.

High Temperature Paint

HIGH-HEAT-RESISTING aluminum paint to stand temperatures up to 1000 deg. F. is being put out under the trade name Valdura by American Asphalt Paint Co., Kankakee, Ill. It is put on cool, and the temperature raised to 450 deg. F. for an hour to fuse the paint to the surface.

Harnischfeger Corp.

HARNISCHFEGER CORPORATION of Milwaukee announces the appointment of C. H. Boenig of Youngstown, New York, as P&H sales engineer, to handle the entire line of Harnischfeger products over the entire western section of New York State



with Rochester as the eastern boundary line. Mr. Boenig holds an M.E. degree from Columbia University, a C.E. degree and Ph.D. degree from the University of Antwerp, Belgium, and also a LL.B. degree from St. Lawrence University. His past connections include vice-president of the Ball, Gear and Machine Co., General Manager of the Malka Water Co., Industrial Engineer in charge of the Philadelphia Office of the United States Fidelity and Guarantee Co., Supervisory Engineer in the Department of Interior of the United States Government for 5 yr., handling construction of sewage disposal plants, filtration plants, bridges and public buildings.

Cutler-Hammer, Inc.

CUTLER-HAMMER, INC., announces the appointment of Joseph Gardberg as Manager of its new office in New Orleans, La., at 539 Gravier St., under the jurisdiction of A. C. Gibson of Cutler-Hammer's Atlanta office. Mr. Gardberg is a graduate of Georgia Tech, with years of experience as a consulting engineer and in various other technical lines of electrical industry.

News from the Field

EVENING INSTRUCTION in Heating, Ventilating and Air Conditioning are being offered by the Polytechnic Institute of Brooklyn, New York, during the regular 1937-38 school sessions, according to an announcement of Prof. E. F. Church, Jr., head of the department of mechanical engineering. Classes will be held on Wednesday and Friday evenings, presented by John James of the Technical Staff of the American Society of Heating and Ventilating Engineers. Registration for the first session in Heating and Ventilating took place during the week of September 13, 1937. This course covers the basic elements of air conditioning with relation to the engineering design and selection of equipment for modern domestic and commercial heating and ventilating systems. Problems will be given illustrating the application of various systems to residences, apartments, office buildings, schools, factories and theaters. Beginning in February, 1938, the course in Air Conditioning will deal with advanced considerations in the field of the previous course, and will present fundamental psychrometric principles and their application to cooling, humidifying and dehumidifying of air for central station or unit type systems. In connection with design of equipment for comfort and commercial air conditioning systems, the sessions will cover the theory of refrigeration, cooling load computations, air distribution and duct design, sound control; and methods of surface cooling, by-pass recirculation, and chemical dehumidification of air.

WHITING CORPORATION, Harvey, Ill., gave an all-day picnic on August 28 for its employees and their families. A main feature of the holiday was the award of service emblems to 279 employees. Three classes of emblems were given out: solid gold with a diamond to the 42, 25-yr. employees, a gold emblem to the 176, 10-yr. employees, and a sterling silver emblem to the 61, 5-yr. employees.

CHARLES P. WOODWORTH, vice president of The Weber Chimney Co., Chicago, died suddenly, on August 12, 1937. Mr. Woodworth had been vice president of the company since 1909, prior to that time having been sales manager. He was 56 years old, had been in poor health for a number of years and had not been active in business since 1934.

He was a registered structural engineer and specialized during his entire business career in the construction of reinforced concrete chimneys, having wide experience in everything relating to the construction and sale of chimneys throughout the United States and in many foreign countries.

WILLIAM B. SCAIFE & SONS CO., of Pittsburgh, Pa., manufacturers of steel tanks, galvanized range boilers, gas cylinders, and water purification apparatus, has announced the appointment of Karl P. Fuhrmann as General Sales Manager.

D. H. SKEEN AND CO., 1 La Salle St., has been appointed Chicago district representatives for National Engineering Products Inc., of Washington, D. C., to handle Copalite joint compound and Rustnil protective coating.

FULLER CO., Catasaugua, Pa., announce the following organization changes: C. C. Kaesemeyer is now service engineer working out of the San Francisco office; A. W. Quick, temporarily located on the Pacific Coast will remain there a short while and then return to the main office. On October 1, E. A. Hamer goes to the San Francisco office, as assistant to the manager, J. M. Alonso, and A. C. Vaughn takes up his duties in the Chicago office as assistant to the manager, H. S. Sayre.

LINDE AIR PRODUCTS CO., Unit of Union Carbide and Carbon Corp., has opened a new sales office in Oakland, Calif., at 3710 San Pablo Avenue, to serve the Oakland area, which supplements the San Francisco office.

LINK BELT CO. has moved its Houston, Tex., offices to 517 Mason Bldg., R. C. Brown being transferred from Detroit to handle industrial, engineering and general sales.

CUTLER-HAMMER, INC., of Milwaukee, announces appointment of W. E. Ragsdale as manager of its Dallas, Tex., office at 624 Santa Fe Bldg. Mr. Ragsdale graduated from Univ. of Oklahoma in electrical engineering and has since been connected with N.B.C. engineering staff, thus gaining wide experience in control and safety-switching systems. Dallas office is under the jurisdiction of G. E. Booth, manager of the St. Louis office.

CLEES VALVE & ENGINEERING CO., 90 West St., New York City, has installed in its laboratories in Newark, N. J., a 1250 lb. testing boiler to be used for high pressure equipment which this company is now manufacturing. The company is now prepared and will have equipment facilities for testing apparatus up to 10,000 lb. per sq. in. hydrostatic pressure and 1250 lb. steam pressure. Temperatures will be obtained as high as 900 deg. F. The facilities will be used for testing all types of equipment and no valve will leave the shop until this test has been made and approved.

LINCOLN ELECTRIC CO., Cleveland, Ohio, announces the appointment of W. W. McClellan as sales engineer in its Grand Rapids, Mich., office, 314 Building and Loan Bldg. Graduate of Muskegon Junior College Engineering School, Mr. McClellan has had extensive welding experience with Campbell, Wyant & Cannon Foundry Co., with E. W. Bliss Co. and General Motors Corp. on jigs, fixtures, tools and dies. He will work under R. D. Lyman who is in charge of the Grand Rapids office.

THE STEEL & TUBES, INC., patents covering its method for butt welding tubing and for removing the burr from the seam have been again upheld in a decision by Federal District Judge John P. Nields, for the District of Delaware. The Court held that Clayton Mark & Co. of Chicago, Ill., which argued that the Johnston patent covering butt welding of tubing applied only to the use of alternating current, had infringed the patent assigned to Steel & Tubes, Inc., a subsidiary of Republic Steel Corp., granted August 23, 1921. Clayton Mark & Co. used direct current in its welding, which use the Court held is entirely covered by the Johnston patent. In holding that the Belmont patent covering apparatus for removing the burr by rolling the welded seam as the tube passes from the machine, had been infringed, the Court said that the patent applies to any apparatus which operates on the burr while it is hot and plastic. This patent was granted December 28, 1926.

APPALACHIAN COALS, INC., has effected a permanent organization, the Management Committee, John A. Howe, chairman, W. J. Cunningham and L. E. Woods having resigned, although remaining on the board of directors. R. E. Howe, who opened the Cincinnati offices in 1933 and has served as secretary, treasurer and vice president, has been elected president; A. L. Brown, manager of the marketing division, has been elected a director and vice president; W. M. Wilshire was elected secretary-treasurer; T. A. Day was reelected assistant secretary, and will devote much time to advertising and sales promotion.

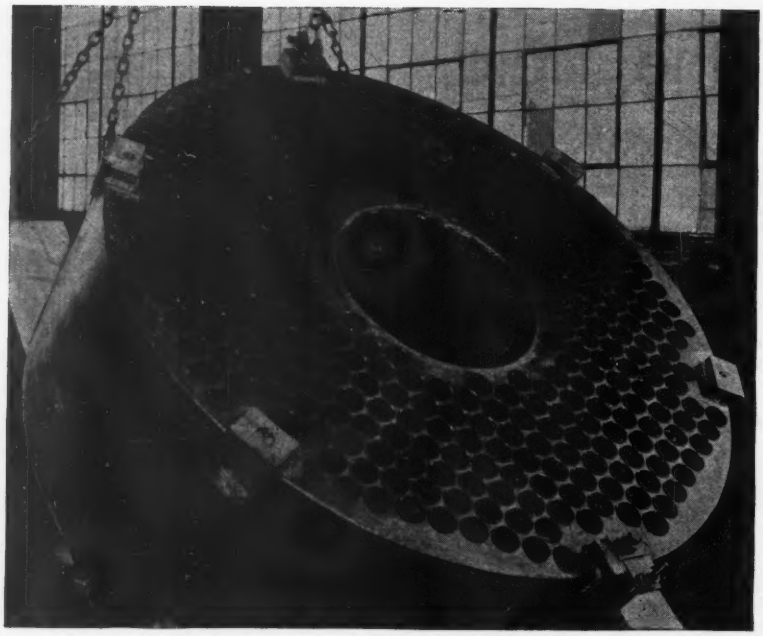
"Prices," stated Mr. Howe, "will be made on a more scientific basis in the future, with the assistance of the minimum prices to be established by the National Bituminous Coal Commission and, through its marketing and engineering divisions, Appalachian Coals, Inc., which markets over forty million tons annually, will so serve domestic and industrial buyers that they get the most value for their money."

It is their desire, and they are urging the Coal Commission, that the date for establishment of prices be not later than Oct. 1st.

THE ALLEN-BRADLEY CO., Milwaukee, manufacturers of motor control equipment, announce the appointment of the Wilson Electrical Equipment Company, 2009 Capitol Avenue, Houston, Texas, as their new representative in the southern territory. Mr. W. F. Wilson, president, is well acquainted in this territory and will maintain an adequate stock of control equipment.

HAGAN CORPORATION of Pittsburgh, Pa., announces receipt of a contract for the installation of a complete automatic boiler control system for the new $5,000,000 power plant extension now being constructed at the James H. Reed Station on Brunot Island, by the Duquesne Light Co. The plant scheduled for completion sometime in 1938, is to be located above the 1936 flood level, and will supply power to take care of the increasing load in the Pittsburgh district. Two 375,000-lb. per hr. boilers fired with multiple-retort, underfeed stokers driven by electric motors through oil-operated, variable speed transmission, will supply steam to a new 60,000-kw. turbine, each boiler having two motor-driven, forced-draft fans and two motor-driven, induced-draft fans. The Hagan installation will include automatic control of superheated steam temperature and discharge pressure of the motor-driven boiler feed pump as well as fans, stoker, preheater dampers and zone dampers in the overfeed section of the stoker.

THE RELIANCE GAUGE COLUMN CO. announces the appointment of the following representatives: Hauer Power Equipment Co., Carew Tower, Cincinnati, Ohio; J. H. Carter, Jr., Carondelet Bldg., New Orleans, La.; Paul R. Winston Co., Construction Bldg., Dallas, Texas.



Copper Condenser Fabricated by Welding

USING MODERN methods this copper condenser was recently fabricated by the Goslin-Birmingham Manufacturing Co., Birmingham, Ala., entirely by the electric arc process of welding. The condenser is to be used to evaporate cane sugar liquor. The liquor passes through the tubes and the steam pressure on the inside is 15 to 30 lb.

The condenser weighs 11,500 lb., is 9 ft. 4 in. in diameter and 3 ft. 6 in. in length. Thickness of copper used in construction is 5/8 in. for the two sheets which, welded together, form the shell of the condenser; 3/8 in. for the field or tube sheet and 5/16 in. for the downtake. The six lugs on the periphery of the unit are heavy cast bronze. These were electrically welded to the copper tube sheet and shell sheets. Tests were made of the condenser under 30 lb. pressure. The arc welding of copper and bronze in fabrication of this condenser was done with "Aerisweld," an electrode manufactured by The Lincoln Electric Co., specifically for welding such metals.

ABRAM HUSSEY, retired Electrical Engineer, died Aug. 19 at his home in Chester, N. J., after a short illness. He was in his seventieth year. Mr. Hussey was, for 21 yr. prior to his retirement in 1934, Superintendent of Distribution for the Brooklyn Edison Company. This comprised the period of the company's greatest expansion and Mr. Hussey played a large part in the development of electric service as it is known in Brooklyn today. At one time he had over 7,000 employees in his department.

THE DELAVAN ENGINEERING CO., 414 12th St., Des Moines, Iowa, has been appointed Sales Representatives in the States of Iowa and Nebraska for Trico Fuse Mfg. Co.'s complete line of Powder-Packed Renewable Fuses, Kantark One-time Fuses, Colortop Plug Fuses, Special Fuses, Kliplok Clamps and Test Clamps, Fuse Pullers, and Lubricators.

ALLEN-BRADLEY CO., Milwaukee, manufacturers of motor control equipment, announce the appointment of the newly formed Delavan Engineering Co., Des Moines, Iowa, as their representative in the Iowa territory. Nelson B. Delavan, president, is a graduate of Cornell University and was formerly vice-president and director of sales of the Penn Electric Switch Co. The company's offices are located at 414 12th St.

BLAW-KNOX CO., Pittsburgh, announces the appointment of G. Howard Boddy, whose offices are in the General Motors Building, Detroit, Mich., as its representative to handle engineering and sales of the products of Power Piping Corp., a subsidiary. Mr. Boddy will also handle sales of some of the company's other industrial products in the Detroit territory, although Blaw-Knox construction equipment will continue to be sold through its distributor, William P. Favorite, 6561 East Seven Mile Road, Detroit.

THE MARLEY CO. of Kansas City, Mo., announces that it has opened a West Coast branch office at 1144 South Grand Avenue, Los Angeles, Calif., with Robert K. Leilich in charge.

LAMINATED SHIM CO., INC., Long Island City, New York, announces the appointment of Richard Seipt as sales manager, effective immediately.

A. J. WADHAMS, vice-president in charge of Development and Research, The International Nickel Co., Inc., has announced the addition of Wayne Z. Friend to his staff. Mr. Friend will devote most of his time to technical service on corrosion-resisting materials, particularly Monel, Nickel and Inconel. After graduation from West Virginia University in 1926 with a Master's degree in Chemical Engineering, Mr. Friend engaged in the production and marketing of natural gasoline with Gasoline Recovery Corp. During the past 7 yr. he has been associated with Phillips Petroleum Co. and, as Chief Technologist of Philgas department of that company at Detroit, Mich., has been recently engaged in the industrial application of liquefied petroleum gases to heat treating requirements of the automotive and other metal industries. He has been active on Committees of the American Gas Association, National Bottled Gas Association and American Society for Testing Materials.

ST. LOUIS ANTI-SMOKE ordinance has been upheld by Federal Judge Moore in the test case of Sam White and Frank Sergent of Bell Heat Coal and Mining Co. against the city, the ordinance being held to improve public health and welfare. Washing and hand picking provisions of the measure were held to serve to reduce sulphur fumes, fly ash and smoke content and to facilitate successful use of mechanical stokers.

SMOKE PREVENTION ASSOCIATION, whose offices are at 139 No. Clark St., Chicago, Ill., elected as officers at its annual convention: William Culbert, Nashville, Tenn., president; W. E. E. Koepler, Bluefield, W. Va., and J. M. Whalen, St. Louis, Mo., vice presidents; Frank A. Chambers, Chicago, Ill, secretary-treasurer.

LINCOLN ELECTRIC CO., manufacturers of arc welding equipment, Cleveland, Ohio, announces the opening of a new sales engineering office at 400 North St., Bluefield, W. Va., in charge of William H. Schuster, who for the past year, has been assistant welding instructor in the Lincoln Welding School at Cleveland. He will maintain welding consultation and supply service for the coal fields of West Virginia, Virginia and Kentucky. Mr. Schuster has had extensive experience in welding of pipe lines, structural steel, maintenance jobs, pressure vessels and in ship yards. While much of his time will be devoted to serving the users of arc welding in the coal fields of the district, his experience will be available to industrial firms in the territory who have problems in the application or use of electric welding.

THE STRONG-SCOTT MFG. CO., Minneapolis, Minn., announces the appointment of D. H. Skeen & Co., 1 North La Salle St., Chicago, as their Sales Representatives for the Chicago territory for their Unipulvo System of direct-firing Boilers.

Other agencies recently established adjacent to Chicago are: O. H. Dittmer Co., 1407 West Fond du Lac Ave., Milwaukee, Wis.; E. B. Stuart & Son, 1301 North Alabama St., Indianapolis, Ind., and O. D. Robbins Co., 415 South Second St., Louisville, Ky.

THE BABCOCK & WILCOX TUBE CO., Beaver Falls, Pa., announce the appointment of Clowe & Cowan, Inc., Amarillo and Lubbock, Texas, as distributors for B&W Seamless Tubular Products in the Texas Panhandle, South Plains and Eastern New Mexico.

THE IDEAL COMMUTATOR DRESSER CO., Sycamore, Ill., announces the recent enlargement of their plant, offices and engineering department as a result of a general expansion program now in progress. New additions will increase the productive capacity of the plant. It has been fully equipped with most modern machine tools and equipment. The increased space allotted will enable the Engineering Department to greatly expand its service in the development of new products and improvement of old products for use in the electrical industry. The new addition completes an 8,000 sq. ft. factory expansion program.

ANNOUCEMENT has been made by the Harnischfeger Corp. of Milwaukee, Wis., of the appointment of C. Sam Swanson as the new P&H representative for the entire state of Michigan, of P&H motors and generators, located at 1702 Kale Building, Detroit.

CORNELL-DUBILIER ELECTRIC CORP., in order to supply demand for its industrial capacitors has taken over the plant and sales staff of Electric Machinery Mfg. Co., Inc., at Minneapolis, Minn. President Octave Blake states that the additional equipment will be used to supplement the 11 buildings on its 33-acre plant, and the sales force will be added to the present organization.

THE BABCOCK & WILCOX TUBE CO., Beaver Falls, Pa., announce the appointment of the Uhrich Supply Co., 914 Central St., Kansas City, Mo., as distributors of B&W Seamless Tubes in the Kansas City trade territory—western Missouri and Kansas.

APPOINTMENT of Max. H. Schachner as assistant sales Manager of the Winton Engine Corp., subsidiary of General Motors, has been announced by William J. Davidson, General Sales Manager of Winton. His principal responsibility will be the direction of the sale of the new Winton two-cycle Diesel engine to manufacturers and distributors.

HARNISCHFEGER CORP. of Milwaukee announces the appointment of the McCullock Sales Co. located at 712 Western Avenue, South Minneapolis, Minnesota, as exclusive agent for P&H Motors for the entire state of Minnesota.

L. W. BROWNE, formerly president of the Fisher Governor Co., is now associated with the O. C. Keckley Co., Chicago, as vice-president in charge of sales and distribution of their steam and liquid control equipment.

New Steam Plant for Buffalo

TO TAKE CARE OF the rising demand for energy in the Buffalo area, the Buffalo Niagara Electric Corp. has announced plans for a new $8,000,000 steam generating plant to be built in Buffalo Harbor near Fuhrman Blvd. The new plant will house a single 1200 lb., 900 deg. F. unit rated at 80,000 kw., although option has been acquired for space for additional units as well as for coal storage. Construction is expected to begin in the near future and the station planned for operation in 1940.

Manchester Street Station

Work will soon be started on a new $4,000,000 extension to the Manchester Street Station of the Narragansett Electric Co. at Providence, R. I. This is the first major capacity addition made by the company since 1925 and since then the electric consumption in the Providence area has practically doubled, the present consumption being considerably above the 1929 peak. Contracts for the design and construction have been awarded to the United Engineers & Constructors, Inc., Philadelphia, Pa.

This installation will consist of a General Electric 40,000 kw. generator, operating condensing, and one Combustion Engineering Co. 430,000 lb. per hr. boiler, designed for either coal or oil burning. This will be one of the largest units in New England and will give the Manchester Street Station a total capacity of approximately 70,000 kw. or slightly more than half the capacity of South Street Station. Plans call for the installation to go into service in the spring of 1939.

Herman Diederichs

HERMAN DIEDERICHS, 63, dean of the College of Engineering and chairman of the board of athletic control at Cornell University, died at the Clifton Springs sanatorium, August 31, 1937, after a year's illness.

For 44 years Dean Deiderichs has been identified with Cornell University as student, teacher and, since July 1, 1936, as dean of the Engineering colleges. His career, begun as a poor German immigrant boy, led to the highest post in one of America's great engineering colleges. He was regarded as an authority in experimental engineering with special reference to materials of engineering. His textbook, in collaboration with the late Prof. R. C. Carpenter, published in 1910, is standard in the field. He was co-outhor with W. C. Andrae of a monumental work on mechanical experimental engineering, dealing with engineering instruments, published in 1931.

A prolific writer, he was co-author of three bulletins of the engineering experiment station at Cornell and was winner in 1930 of the Melville medal of the A. S. M. E. for a "thesis of exceptional merit," with W. D. Pomeroy of Seneca Falls. He had performed many investigations and tests as a consultant in private industry.

Throughout his career on the faculty, Dean Diederichs, elected president of the athletic association in 1913, served through 1925, and was elected again in 1932, serving until he became chairman of the new board of athletic control. He was known as the father of the regional scholarship plan of the athletic association.

He was a member of Quill and Dagger, senior honorary society; Tau Beta Pi, Phi Kapa Phi and Phi Sigma Kappa fraternities, and belonged to such professional societies as the American Society of Mechanical Engineers, Society of Automotive Engineers, Society for the Promotion of Engineering Education, the German Society of Engineers, and the American Society for Metals. He was chairman of the board of honors and awards and of the nominating committee of the A.S.M.E. for 1936 and was vice-president of the second district, National Collegiate Athletic association.

Diesel Users' Association of America

AT ITS FIRST ANNUAL MEETING held August 23, at State College, Pa., the newly organized Diesel Users' Association of America elected officers as follows: President, H. C. Major, Commissioner of Public Utilities, Rockville Center, N. Y.; vice president, G. W. Welsh, Chief Engineer, Otter Tail Power Co., Fergus Falls, Minn.; secretary, Louis Black, Chief Engineer, Doubleday, Doran & Co., Inc., Garden City, N. Y.

These officers, together with R. G. Chester, Chief Plant Engineer, Vernon, Calif., plant of Southern California Edison Co., Ltd., Southmayd Hatch, Marine Transportation Dept., Socony-Vacuum Oil Co., Inc., New York City and R. G. Williams, City Manager, Bryan, Texas, will constitute the Board of Directors.

As expressed in its Constitution:—"The objects of this Association shall be: (a) to keep Members informed of developments in the Diesel industry, (b) to provide a forum for the discussion of the common problems of its Members, (c) to promote friendly relations between its Members and thereby lend encouragement to those in subordinate positions, (d) to publish bulletins at such times as may be determined for distribution among its Members, and (e) to enact rules, regulations and by-laws to carry the foregoing purposes into effect."

The Members of the Association are to be divided into the following grades: Honorary; charter; full; junior, and applicant.

Full Members must, at the time of application, be owners as individuals, or managers, superintendents, engineers, maintenance men or operators in the employ of individual or corporate owners of Diesel power plants or Diesel-powered equipment, and must have had at least 3 yr. experience in Diesel power plants or with Diesel-powered equipment. Junior Members will be individuals who have had at least 4 wk. of experience in the operation of Diesel engines. Applicant Members will be individuals who lack the training and experience necessary to qualify them for Junior Membership. Any individual not eligible for membership and any firm, partnership or corporation may affiliate with the Association as an Associate.

Officers point out that the Association is not a labor organization or an employers' organization. This association will take no part in, and will express no opinion with regard to, any dispute that may arise between any of the employers of the industry and their employees over hours, rates of pay or conditions of employment.

The present business address of the Association is at 7 West 44th St., New York City, and those who desire to join should write the secretary.

Neill Appointed Head of Worthington Engineering and Sales at Holyoke

WORTHINGTON PUMP AND MACHINERY CORP. announces the appointment of W. A. Neill as manager of engineering and sales activities at its recently reopened plant at Holyoke, Mass. Mr. Neill, formerly manager of the corporation's Air Tool and Portable Compressor Division at Harrison, N. J., will have his headquarters at Holyoke, where the manufacture of portable compressors, rock drills, automotive compressors and vertical compressors is now under way.

Educated at Leland Stanford University, Mr. Neill was connected with the Denver Engineering Works for a number of years. He later became affiliated with the Allis-Chalmers Co. of Milwaukee on engineering and sales work in their mining department. In 1916, Mr. Neill joined the Dorr Co., Inc., of New York and Denver, Colo., in which organization he held several important executive positions covering both domestic and foreign operations.

Mr. Neill has been associated with Worthington since 1934 in charge of sales to the mining and construction fields.

For the Engineer's Library

A NOVEL MANNER of preventing accumulation of high temperatures under the roof of factories heated with unit heaters, is described in a new bulletin on the Airblanket heating method, just issued by the Airtherm Manufacturing Co., 1474 S. Vandeventer, St. Louis, Mo.

THE LEE DIRECT Fired Unit Heater is the subject of a catalog, recently issued by Dravo Corp., Pittsburgh, Pa., which not only describes the equipment making up these units but gives considerable technical information in regard to capacities, application, power required and fuel used.

TROY ENGINE & MACHINE Co., Troy, Pa., has recently issued a bulletin describing Troy-Engberg generators, giving considerable information on the capacities, field construction, armature, commutator, brush rigging and bearings.

IN AN ATTRACTIVE 16 page catalog, the Ajax Flexible Coupling Co., Westfield, N. Y., describes in detail the various types of Ajax shaft couplings, giving by means of blueprint illustrations the details of construction, and supplying the engineer with information on the power ratings of the various sizes of couplings.

R. W. CRAMER & Co., INC., 67 Irving Place, New York City, is issuing a new catalogue of Sauter Synchronous and Electrically Wound Time Switches.

IN A BOOKLET entitled Five Ways to Buy Equipment, Commercial Investment Trust, Inc., New York City, outlines its method of financing the purchase of equipment over a funding period of 6 to 36 mo. as compared to other methods of purchase and funding of loans.

A PUBLICATION describing the features, construction and application of the Midget Marvel Flexarc Welder has been announced by the Westinghouse Electric & Mfg. Co. Specifications and operating costs are included together with a list of questions and answers covering the use and operation of this low cost welder.

BULLETIN 40-B-12, "Rotary Displacement Meters," recently issued by the Roots-Connersville Blower Corp., Connersville, Ind., describes not only the general operating principles of the meters, but also lists meters for smaller volumes than in previous bulletins. Typical proof curves, illustrations of advanced meter design, and views of installations of meters in many different kinds of service, in this and foreign countries, are shown in this new bulletin.

SIXTEEN PAGE illustrated list-price catalog No. 1532 on friction clutches has been completed by Link-Belt Co., Chicago, giving sizes, dimensions, weights, horsepower ratings, and other pertinent tabular data on both Meeseco and Twyncone types of clutches. To obtain a copy, address the Link-Belt office, Chicago, Ill., asking for Book No. 1532.

IN THE AUGUST issue of Baldwin-Southwark are found articles on stage elevators in the Radio City Music Hall, a new system of load indication for testing machines, enlarged Diesel plant for Russell, Kan., tests on Boulder Dam turbines and the development and uses of celluloid.

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., has just issued a new 16 page bulletin No. 1542 on Feedwater Treatment. It describes the application of Akon in connection with various water treating problems and the latest development in the treatment of water for steam generation. The subject of water treatment is divided into several components which include: scale prevention, elimination of carry-over, and the prevention of corrosion. Of particular importance is a complete discussion on the elimination of silica scale deposits in high pressure boilers and the use of a conductivity meter to determine the amount of boiler water solids carried over with the steam.

"ALTERNATING CURRENT Bracket Bearing Type Generators" is the subject of a new 8 page bulletin recently issued by Allis-Chalmers Mfg. Co., Milwaukee, Wis. It deals with generators built in standard ratings from 30 to 1000 kv-a. suitable for coupled service to high speed steam or internal combustion engines, or through gears to steam turbines, or for belt drive from steam or internal combustion engines. These are available in standard voltages up to 2400, also higher voltages within certain limit.

MANUAL OF Smoke and Boiler Ordinances and Requirements is a 152-p. book published by the Smoke Prevention Association, City Hall Square Bldg., Chicago, Ill. It includes codes for heating boilers and their furnaces, methods or firing to avoid smoke, determination of air pollution, smoke abatement ordinance, and the proceedings of the annual convention which cover reports on the work of smoke commissions and methds of smoke abatement. Copies may be had from the Association for 50 cents.

FOLDER OF Webster, Tallmadge & Co., E. Orange, N. J., shows its equipment for electric zone control of heating systems.

LINK-BELT Co., Stoker Division, 2410 W. 18th Street, Chicago, has just issued a new folder No. 1518-A describing the Radiostat, an electronic temperature control for stoker installations in hotels, apartment and office buildings, and other locations where the ordinary type of thermostatic control is not practical. The Radiostat achieves uniformity of temperature by balancing three different elements in its control of stoker operation, outside temperature, return line temperature and boiler pressure. A copy of the folder will be sent to interested readers upon request.

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., has issued a new bulletin No. 1180 covering condensing reaction type turbogenerator units of 1500 to 5000 kw. capacity and treating both turbine and generator construction in considerable detail. Photographs and drawings illustrate separation of oil and steam piping to eliminate possibility of oil fires, new combined journal and Kingsbury thrust bearing, separate steam chest, four bearing construction and the simplicity of the governing system.

BULLETIN No. 17 of the Dardelet Threadlock Corp., 55 Liberty St., New York City, deals with the use of Dardelet thread on cap and set screws for flanges, covers, collars and pulleys.

HERCULOY, a new corrosion-resisting, copper-silicon alloy for forgings, castings, and drawn shapes is illustrated and its properties and uses described in a booklet issued by Revere Copper & Brass, Inc., 230 Park Ave., New York City. Copies are available on request.

CATALOG No. 333, a new 48-page catalog of the Modine Mfg. Co., Racine, Wis., describes and illustrates Modine blast heaters. It also contains complete engineering, physical data, piping and control diagrams and directions for selecting heaters to meet specific requirements.

ADVANTAGE OF WELDED JOINTS in installing piping systems are discussed in Welded Piping, a 12-page illustrated booklet, published by The Linde Air Products Co., New York, N. Y.

Subjects of sections are: pipe and services to be welded; lighter than standard weight pipe; fast, economical welding methods; welded joints and fittings; shop and field fabrication, and piping erection.

THE HAGAN CORPORATION of Pittsburgh, Pa., has just issued a new bulletin describing its Receiving Regulator, which is used in conjunction with the Master Sender of the Hagan Automatic Boiler Control System. Copies are obtainable by addressing the manufacturers direct.

ENGINEERS, superintendents and maintenance men responsible for pipe line maintenance will be interested in the new Pipe Repair Handbook published by M. B. Skinner Co., South Bend, Ind., which discusses all kinds of leaks in pipe lines and joints, and tells how repairs may be made without service interruption. The handbook is furnished without cost to men responsible for pipe maintenance.

DE LAVAL-IMO PUMP, a rotary displacement pump intended primarily for fuel, lubricating and heavy crude oils, is described in Catalog L-32 issued by the De Laval Steam Turbine Co., Trenton, N. J. This pump, to run at conventional motor and turbine speeds, has only three moving parts, a central and two sealing rotors. The spindle of the central power rotor is extended through a stuffing box for connection to the driving motor, and there is no other bearing and no valves. All capacities for pressures up to 500 lb. are built; pumps for higher pressures can be supplied.

CATALOGUE 38W entitled, "Electric Spot and Butt Welding Machine" has recently been issued by the Eisler Engineering Co. of 750 South Thirteenth St., Newark, N. J., and contains sketches and drawings of various types of spot and butt welding. Numerous illustrations, specifications and descriptions emphasize the important features of the many types of spot and butt welders as well as wire portable and special welders, high frequency and brazing and soldering machines, spot welding timers and miscellaneous welding accessories. The catalogue contains 100 pages and it has over 1250 different illustrations on various welding problems.

CROCKER-WHEELER ELECTRIC MANUFACTURING Co., Ampere, N. J., have issued two new bulletins, No. 247 on Alternating Current Generators and No. 249 on Direct Current Generators. These are 12 page bulletins, attractively illustrated and with full descriptive data concerning the construction of the two types of generators.

J. H. WILLIAMS & Co., 75 Spring Street, New York City, have just issued a new catalog describing their entire industrial line of drop-forged wrenches and other standard stock specialties. Included, are many additions to their Carbon and Alloy Wrenches, detachable "Supersocket" Wrenches and "Agrippa" Tool Holders.

THE LOUIS ALLIS CO., Milwaukee, Wis., has issued a very complete 60-page book describing the construction, features, advantages and applications of practically every commercial type electric motor. This book also includes engineering data on various types of special motor applications and construction.

It includes a detailed analysis of the characteristics of squirrel cage motors, motors for centrifugal pumps, etc.

AMONG THE new publications issued recently by the General Electric Co. are the following:

No. GEA. 2605 entitled Modern Switchgear, an attractive 18 page illustrated booklet giving information on most commonly used switching equipment. Leaflet GEA-1285A describing Track Type Limit Switches. GEA 961B, on Helical Sheath Wire Resistor Units. and GEA. 2702 on the Double Photoelectric Recorder.

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., has released a new bulletin No. 1187 on modern indoor type cubicle switchgear giving outstanding advantages, applications, and details of construction, as well as complete dimensions.

LISTING and describing chemical, bacteriological, engineering, electrical, general scientific and other technical books of American and British publishers, catalog No. 5 of the Chemical Publishing Co., New York, N. Y., will be mailed to any technical worker sending 10 ct. in stamps or coin to cover mailing.

HYGROSTATS, water pans and humidifiers for humidity control are described in a new 8 page Bulletin No. 202 of The Powers Regulator Co., 2720 Greenview Ave., Chicago, Ill.

MODEL 36-A Diesel generating sets made in sizes from 5.3 to 100 kv-a. are described in a new 16 page bulletin No. 3600-A2 recently issued by Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago.

FRICK CO., Waynesboro, Pa., is distributing two new bulletins. No. 508-B is a 16 page booklet describing the construction and typical installations of Freon 12 compressors of the enclosed type. The second bulletin, also 16 pages, is entitled Frick Refrigeration in Philadelphia and Vicinity and describes various industrial installations in that area.

BULLETIN A-1, on standard size Haveg pipe fittings, valves and fume duct, has recently been published by the Haveg Corp., Newark, Del. In addition to giving complete mechanical details, it also included a table of chemical resistance properties.

NEW EDITION of the 68-page insulation booklet, Barriers to Industrial Waste, has been published by Johns-Manville, 22 E. 40th St., New York, N. Y., containing a complete and improved table of recommendations to serve as a guide to the proper selection of J-M Insulations for uses in practically all industries. Amply illustrated, and describing more than 50 different insulations, it has added features on JM-20 Brick, a new type of 200 deg. F. insulating brick, Stonefelt, a new insulation composed of mineral fibres for use on railroad passenger cars, refrigerator cars and buses, and information on other products recently developed by Johns-Manville.

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., has issued an attractive new leaflet 2259 describing and illustrating industrial sub-station service transformers.

RUBBER SPRINGS, reprint of a paper on design calculations and representative uses of rubber springs, presented at the annual meeting of the American Society of Mechanical Engineers by Walter C. Keyes, Mechanical Products Engineer, United States Rubber Products, Inc., is being distributed by the Company. Many charts, tables and line drawings are incorporated, showing the approximate physical properties of various rubber compounds, load-deflection curves, load-bearing and bulge areas and area ratio, and a comprehensive chart showing deflection in terms of thickness, per cent. The paper is based on years of practical experience in the fields of transportation and diverse manufacturing, and is written in simple and non-technical form.

ENGINEERS' COUNCIL for Professional Development is sending out a Selected Bibliography of Engineering Subjects. The books listed are, in general, of college grade and have been chosen through consultation with a large group of experienced engineers and educators as worthy examples of the best professional literature, and providing guidance to young engineers who wish to extend their academic training by further study either in familiar fields or in new ones. It also provides a list to which libraries may turn for suggestions concerning a basic stock of engineering literature.

HARD FACING with Haynes Stellite, in a new edition, covers various applications including valves, valve seats, nozzles, tube cleaners, cams, gears, pulverizers, buckets and scrapers. Copies are available from Haynes Stellite Co., Kokomo, Ind.

MEEHANITE METAL which is being used in all iron castings that go into Cooper-Bessemer engines, compressors and spare parts, and a comparison of the qualities of this metal with those of other irons are fully described in a handsome 16-p. bulletin issued by The Cooper-Bessemer Corp., Mt. Vernon, Ohio. Microphotographs are shown, also comparisons of transverse deflection, tensile, endurance and heat-growth tests. Meehanite is the result of research by the Company's Engineering and Metallurgical departments for a better method of making iron casting and was subjected to extensive study and tests before it was adopted. Copies of the Bulletin may be had on request.

"THE STORY OF BITUMINOUS COAL" has just been published and distributed by the National Coal Association, Southern Building, Washington, D. C. This booklet was prepared primarily for the purpose of furnishing information about the mining of coal and the coal industry in general to school boys and girls and college students, as well as libraries, in every part of the country. Copies may be had by addressing Committee of Ten, Coal and Heating Industries, 307 No. Michigan Ave., Chicago, Ill.

CELORON MOLDED PLASTIC COUPLINGS are described in a new technical bulletin just published by Continental-Diamond Fibre Co., Newark, Del. These couplings are made of a molded macerated synthetic material widely used for the construction of silent gears and valve discs.

Diesels Successful?

Cedarburg, Wis., found its municipal light and power load growing so rapidly that more capacity was added this last summer. With many years of experience to back up the decision, the city naturally turned to the Diesel. The new engine in the foreground is a 1000-hp. unit. Back of the new engine is the 50-hp. installed in 1928 and back of that the 450-hp. which has been in service since 1924. All of these are the Nordberg, two cycle air injection type with crosshead construction.

Power Plant Construction News

Ala., Birmingham—Virginia-Carolina Chemical Corporation, Richmond, Va., plans installation of electric power equipment in new sulphuric acid plant on site adjoining fertilizer works at East Birmingham, to consist of several units. Entire project will cost close to $200,000. M. S. Purvis is vice-president, in charge.

Conn., Portland—Rogers & Hubbard Co., Middletown, Conn., plans installation of electric power equipment in connection with rebuilding of commercial fertilizer plant at Portland, recently destroyed by fire. Loss estimated at $150,000.

Fla., Maclenny — Common Council has plans under way for new municipal ice-manufacturing and cold storage plant, to be one-story, estimated to cost $32,700, with equipment. Financing has been arranged through Federal aid.

Fla., Miami—Schaaf Preserving Co., 3034 N. W. Seventeenth Avenue, plans installation of electric power equipment in new one-story food processing and canning plant at 1301 N. W. Twenty-second Street. Entire project will cost over $60,000. B. Kingston Hall, 1447 Collins Avenue, Miami Beach, Fla., is architect.

Ill., Chicago—Atchison, Topeka & Santa Fe Railway Co., 80 East Jackson Boulevard, has filed plans for a new one-story power house at yard and shops on West Eighteenth Street, and will proceed with erection at once. Cost close to $45,000, with equipment. R. A. Viehe-Naess, first noted address, is engineer.

Ill., Lockport—Great Lakes Coal & Coke Co., 910 South Michigan Avenue, Chicago, Ill.; plans installation of power equipment in new fuel briquette-manufacturing plant at Lockport. Also will install conveying, elevating and other mechanical-handling equipment. Entire project is reported to cost in excess of $85,000.

Iowa, Clinton—E. I. duPont deNemours & Co., Inc., Cellophane Division, duPont Building, Wilmington, Del., plans installation of electric power equipment in new cellophane mill at Clinton, where large tract of land has been acquired. A power house will be built. Entire project is reported to cost over $1,500,000.

Iowa, Pella—City Council will receive bids until Oct. 5 for extension and improvements in municipal electric power plant, including installation of additional equipment. Young & Stanley, Inc., Muscatine, Iowa, is consulting engineer.

Iowa, Waverly — City Council has plans nearing completion for extensions and improvements in municipal light and power plant, with installation of new Diesel engine-generating unit and auxiliary equipment. Cost estimated at $160,000. Young & Stanley, Inc., Muscatine, Iowa, is consulting engineer.

Kan., St. Francis—Common Council has plans maturing for extensions and improvements in municipal electric power plant, including installation of two new Diesel engine-generator units and auxiliary equipment. Cost about $90,000. Financing is being arranged through Federal aid. E. T. Archer & Co., New England Building, Kansas City, Mo., are consulting engineers.

Ky., Williamstown—Common Council has plans maturing for new municipal electric power plant and electrical distributing system. Site for plant has been selected at Cunningham and Licking Streets. Cost about $90,000. Financing has been arranged through Federal aid.

La., New Orleans—Harry Brothers Co., 3505 South Carrollton Avenue, plan installation of electric power equipment in new addition to sheet metal products plant. Work is scheduled to begin soon. Cost estimated close to $60,000.

Me., Skowhegan—City Council has plans for new municipal steam power plant for central heating service. Cost about $84,000, including pipe line distributing system. Financing has been arranged through Federal aid.

Md., Baltimore — Frankfort Distilleries, Inc., Dundalk, plans new steam power house for service at distillery. Cost close to $50,000, including boilers and auxiliary equipment.

Mich., Bessemer—City Council has plans for new municipal electric power plant, with installation to include two 320-kw. Diesel engine generator units and auxiliaries, two 15,000-gal. oil storage tanks, pumping machinery and complete accessory equipment. Also a new electrical distributing system will be installed. Entire project will cost $187,000. Financing has been arranged through Federal aid. James H. Trebilcock is city engineer.

Mich., Escanaba — City Council has authorized surveys and estimates of cost for new municipal steam power plant for central heating service, including pipe line distributing system. George Bean is city manager, in charge.

Minn., Springfield—Common Council is considering extensions and improvements in municipal electric power plant, including installation of new steam turbo-generator unit and auxiliary equipment. Cost estimated close to $140,000. Burlingame, Hitchcock & Estabrook, Sexton Building, Minneapolis, Minn., are consulting engineers.

Mont., Sidney — City Council has plans for new municipal pumping station for waterworks system. Cost estimated close to $98,000, with pumping machinery and auxiliary equipment. Financing has been concluded through Federal aid in amount of $98,180.

Neb., Hastings — Central Nebraska Public Power & Irrigation District, Third Street and St. Joseph Avenue, Hastings, O. R. Canaday, secretary, has plans maturing for two new hydroelectric generating plants on North Platte River, in Jeffrey Canyon and Johnson Canyon, respectively, with power dams, transmission lines, switching stations and other structures. Fund of $20,096,000 has been secured through Federal aid for new stations and irrigation system. George E. Johnson is chief engineer.

Neb., Hay Springs — Mirage Flats Public Power & Irrigation District, Hay Springs, plans hydroelectric generating plant in connection with proposed irrigation system in parts of Sheridan and Dawes Counties. Project will include about 50 miles of transmission lines, power substations and series of electric-operated pumping plants. Fund of about $666,000 is being arranged through Federal aid. H. H. Henningson Engineering Co., Union State Bank Building, Omaha, Neb., is consulting engineer.

N. J., Belleville—Pettit Paint Co., 45 Cornelison Avenue, Jersey City, N. J., plans installation of electric power equipment in new two-story paint and varnish plant at Main Street and Belle Vista Avenue, Belleville. Entire project will cost close to $50,000.

N. Y., Oswego — Niagara Hudson Public Service Corporation, Electric Building, Buffalo, N. Y., a division of Niagara Hudson System, same address, has preliminary plans for new steam-electric generating station in vicinity of Oswego, where site is being selected. Another site, also, is being considered on the Racquette River. Plant will have a capacity of 115,000-hp., and is estimated to cost about $10,000,000. Transmission lines will be built for connection with present system. Work is scheduled to begin early next year. Company is now arranging for change of name to Central New York Power Corporation.

Ohio, Nelsonville—Common Council plans extensions and improvements in municipal electric power plant, including installation of new equipment. Cost estimated at $90,000. Financing will be arranged soon.

Ohio, Springfield—Buckeye Bumpers, Inc., Jefferson and Ziegler Avenues, plans installation of electric power equipment in new addition to automobile bumper works. Cost over $60,000. Company is a subsidiary of Electric Auto-Lite Co., Champlain and Mulberry Streets, Toledo, Ohio.

Pa., Laurys Station — The Mauser Mill Co., Treichlers (Northampton County), plans installation of power equipment in connection with proposed rebuilding of flour mill at Laurys Station, recently destroyed by fire. Loss estimated close to $300,000.

Texas, Andrews — Common Council plans installation of turbine pumping unit, booster pumping machinery, 50,000-gal. elevated steel tank and tower, and other equipment for new municipal waterworks. A bond issue has been voted for project. A. S. Adams, Handley, Texas, is consulting engineer.

Texas, Rockport—Common Council has plans under way for new municipal ice-manufacturing and cold storage plant, one-story, 25x110 ft., to be equipped for initial capacity of about 17 tons per day. Cost close to $40,000. Financing has been arranged through Federal aid.

Wash., Bellingham — Puget Sound Pulp & Timber Co., plans installation of electric power equipment in new additions to sulphite pulp mill for large increased capacity. Entire project will cost about $2,200,000. Financing has been authorized and work will be placed under way soon. Ralph M. Roberg is general manager.

Wis., La Crosse — State Board of Normal School Regents, Madison, Wis., plans new steam power house at State Teachers' College, La Crosse, for central heating service. Cost about $95,000 with boiler units, pumps and auxiliary equipment. Financing has been arranged through Federal aid. Arthur Peabody, State Capitol, Madison, is state architect.